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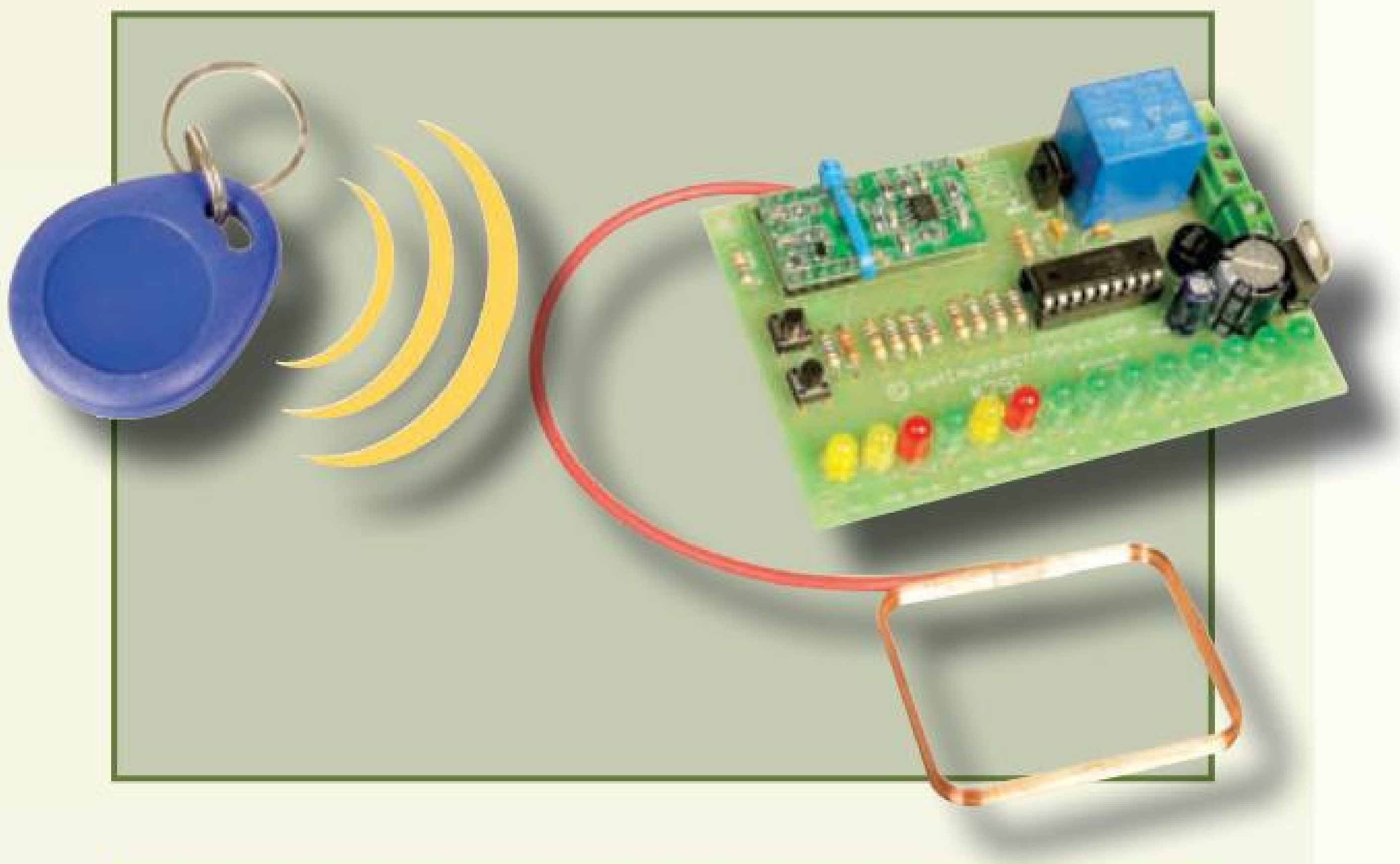
Hearing Loop Tester



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Our December 2012 issue will be published on Thursday 1 November 2012, see page 80 for details.

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We have a wide range of low cost PIC and ATMEL Programmers. Complete range and documentation available from our web site.

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18Vdc Power supply (PSU121) £22.95
Leads: Parallel (LDC136) £3.95 / Serial (LDC441) £3.95 / USB (LDC644) £2.95

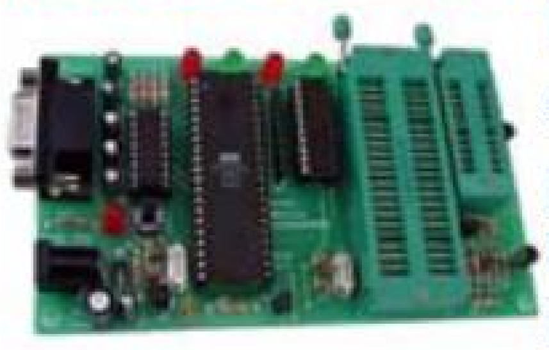
USB & Serial Port PIC Programmer

USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.
Kit Order Code: 3149EKT - **£49.95**
Assembled Order Code: AS3149E - **£64.95**
Assembled with ZIF socket Order Code: AS3149EZIF - **£74.95**

USB Flash PIC Programmer

USB PIC programmer for a wide range of Flash devices—see website for details. Free Windows Software. ZIF Socket and USB lead not included. Powered via USB port - no external power supply required.
Assembled with ZIF socket Order Code: AS3150ZIF - **£64.95**

ATMEL 89xxxx Programmer



Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16Vdc.
Kit Order Code: 3123KT - **£28.95**
Assembled Order Code: AS3123 - **£39.95**

Introduction to PIC Programming

Go from complete beginner to burning a PIC and writing code in no time! Includes 49 page step-by-step PDF Tutorial Manual, Programming Hardware (with LED test section), Win 3.11—XP Programming Software (Program, Read, Verify & Erase), and 1rewritable PIC16F84A that you can use with different code (4 detailed examples provided for you to learn from). PC parallel port.
Kit Order Code: 3081KT - **£16.95**
Assembled Order Code: AS3081 - **£24.95**

PIC Programmer Board

Low cost PIC programmer board supporting a wide range of Microchip® PIC™ microcontrollers. Requires PC serial port. Windows interface supplied.
Kit Order Code: K8076KT - **£34.95**

PIC Programmer & Experimenter Board

The PIC Programmer & Experimenter Board with test buttons and LED indicators to carry out educational experiments, such as the supplied programming examples. Includes a 16F627 Flash Microcontroller that can be reprogrammed up to 1000 times for experimenting at will. Software to compile and program your source code is included.
Kit Order Code: K8048KT - **£34.95**
Assembled Order Code: VM111 - **£44.95**

Controllers & Loggers

Here are just a few of the controller and data acquisition and control units we have. See website for full details. 12Vdc PSU for all units: Order Code PSU446 £8.95

USB Experiment Interface Board

5 digital input channels and 8 digital output channels plus two analogue inputs and two analogue outputs with 8 bit resolution.
Kit Order Code: K8055NKT - **£29.95**
Assembled Order Code: VM110N - **£43.95**

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED 's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two *& Ten Channel versions also available.*
Kit Order Code: 3180KT - **£54.95**
Assembled Order Code: AS3180 - **£64.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 45x45mm. Powered by PC. Includes one DS1820 sensor.
Kit Order Code: 3145KT - **£19.95**
Assembled Order Code: AS3145 - **£26.95**
Additional DS1820 Sensors - **£4.95 each**

Remote Control Via GSM Mobile Phone

Mobile Phone NOT included

Place next to a mobile phone (not included). Allows toggle or auto-timer control of 3A mains rated output relay from any location with GSM coverage.
Kit Order Code: MK160KT - **£11.95**

Most items are available in kit form (KT suffix) or pre-assembled and ready for use (AS prefix).

4-Ch DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12Vdc.
Kit Order Code: 3140KT - **£79.95**
Assembled Order Code: AS3140 - **£94.95**

8-Ch Serial Port Isolated I/O Relay Module

Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130x100x30mm. Power: 12Vdc/500mA.
Kit Order Code: 3108KT - **£74.95**
Assembled Order Code: AS3108 - **£89.95**

Infrared RC 12–Channel Relay Board

Control 12 onboard relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12Vdc/0.5A
Kit Order Code: 3142KT - **£64.95**
Assembled Order Code: AS3142 - **£74.95**

Audio DTMF Decoder and Display

Detect DTMF tones from tape recorders, receivers, two-way radios, etc using the built-in mic *or* direct from the phone line. Characters are displayed on a 16 character display as they are received and up to 32 numbers can be displayed by scrolling the display. All data written to the LCD is also sent to a serial output for connection to a computer. Supply: 9-12V DC (Order Code PSU303). Main PCB: 55x95mm.
Kit Order Code: 3153KT - **£37.95**
Assembled Order Code: AS3153 - **£49.95**

3x5Amp RGB LED Controller with RS232

3 independent high power channels. Preprogrammed or user-editable light sequences. Standalone option and 2-wire serial interface for microcontroller or PC communication with simple command set. Suitable for common anode RGB LED strips, LEDs and incandescent bulbs. 56 x 39 x 20mm. 12A total max. Supply: 12Vdc.
Kit Order Code: 8191KT - **£29.95**
Assembled Order Code: AS8191 - **£39.95**

Hot New Products!

Here are a few of the most recent products added to our range. See website or join our email Newsletter for all the latest news.

4-Channel Serial Port Temperature Monitor & Controller Relay Board

4 channel computer serial port temperature monitor and relay controller with four inputs for Dallas DS18S20 or DS18B20 digital thermometer sensors (£3.95 each). Four 5A rated relay channels provide output control. Relays are independent of sensor channels, allowing flexibility to setup the linkage in any way you choose. Commands for reading temperature and relay control sent via the RS232 interface using simple text strings. Control using a simple terminal / comms program (Windows HyperTerminal) or our free Windows application software.
Kit Order Code: 3190KT - **£84.95**
Assembled Order Code: AS3190 - **£99.95**

40 Second Message Recorder

Feature packed non-volatile 40 second multi-message sound recorder module using a high quality Winbond sound recorder IC. Standalone operation using just six onboard buttons or use onboard SPI interface. Record using built-in microphone or external line in. 8-24 Vdc operation. Just change one resistor for different recording duration/sound quality. sampling frequency 4-12 kHz.
Kit Order Code: 3188KT - **£29.95**
Assembled Order Code: AS3188 - **£37.95**
120 second version also available

Bipolar Stepper Motor Chopper Driver

Get better performance from your stepper motors with this dual full bridge motor driver based on SGS Thompson chips L297 & L298. Motor current for each phase set using on-board potentiometer. Rated to handle motor winding currents up to 2 Amps per phase. Operates on 9-36Vdc supply voltage. Provides all basic motor controls including full or half stepping of bipolar steppers and direction control. Allows multiple driver synchronisation. Perfect for desktop CNC applications.
Kit Order Code: 3187KT - **£39.95**
Assembled Order Code: AS3187 - **£49.95**

Video Signal Cleaner

Digitally cleans the video signal and removes unwanted distortion in video signal. In addition it stabilises picture quality and luminance fluctuations. You will also benefit from improved picture quality on LCD monitors or projectors.
Kit Order Code: K8036KT - **£29.95**
Assembled Order Code: VM106 - **£44.95**

Most items are available in kit form (KT suffix) or assembled and ready for use (AS prefix).

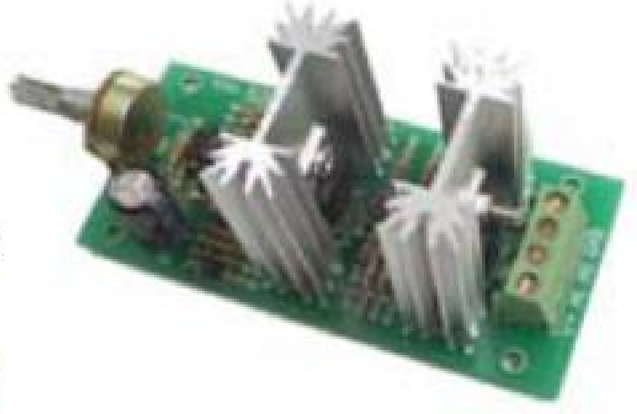
Motor Speed Controllers

Here are just a few of our controller and driver modules for AC, DC, Unipolar/Bipolar stepper motors and servo motors. See website for full details.

DC Motor Speed Controller (100V/7.5A)

Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£19.95**
Assembled Order Code: AS3067 - **£27.95**

Bidirectional DC Motor Speed Controller

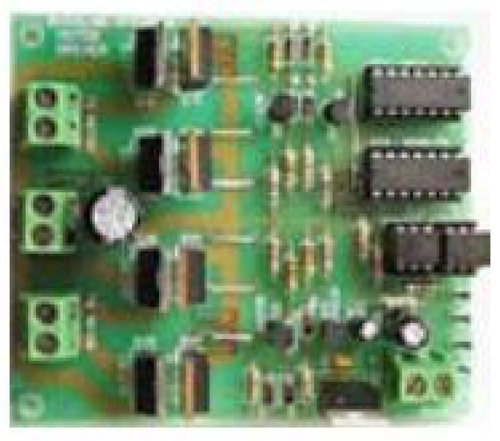


Control the speed of most common DC motors (rated up to 32Vdc/10A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections.
Kit Order Code: 3166v2KT - **£23.95**
Assembled Order Code: AS3166v2 - **£33.95**

Computer Controlled / Standalone Unipolar Stepper Motor Driver

Drives any 5-35Vdc 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps. Provides speed and direction control. Operates in stand-alone or PC-controlled mode for CNC use. Connect up to six 3179 driver boards to a single parallel port. Board supply: 9Vdc. PCB: 80x50mm.
Kit Order Code: 3179KT - **£17.95**
Assembled Order Code: AS3179 - **£24.95**

Computer Controlled Bi-Polar Stepper Motor Driver



Drive any 5-50Vdc, 5 Amp bi-polar stepper motor using externally supplied 5V levels for STEP and DIRECTION control. Opto-isolated inputs make it ideal for CNC applications using a PC running suitable software. Board supply: 8-30Vdc. PCB: 75x85mm.
Kit Order Code: 3158KT - **£24.95**
Assembled Order Code: AS3158 - **£34.95**

AC Motor Speed Controller (600W)

Reliable and simple to install project that allows you to adjust the speed of an electric drill or 230V AC single phase induction motor rated up to 600 Watts. Simply turn the potentiometer to adjust the motors RPM. PCB: 48x65mm. Not suitable for use with brushless AC motors.
Kit Order Code: 1074KT - **£15.95**
Assembled Order Code: AS1074 - **£23.95**

See www.quasarelectronics.com for lots more DC, AC and Stepper motor drivers

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Order Code EPL500 - **£179.95**
Also available: 30-in-1 **£17.95**, 50-in-1 **£29.95,** 75-in-1 **£39.95** £130-in-1 **£49.95** & 300-in-1 **£79.95** (see website for details)

Tools & Test Equipment

We stock an extensive range of soldering tools, test equipment, power supplies, inverters & much more - please visit website to see our full range of products.

Advanced Personal Scope 2 x 240MS/s

Features 2 input channels - high contrast LCD with white backlight - full auto set-up for volt/div and time/div - recorder roll mode, up to 170h per screen - trigger mode: run - normal - once - roll ... - adjustable trigger level and slope and much more.
Order Code: APS230 - ~~£499.95~~ **£394.95**

Personal Scope 10MS/s

The Personal Scope is not a graphical multimeter but a complete portable oscilloscope at the size and the cost of a good multimeter. Its high sensitivity - down to 0.1mV/div - and extended scope functions make this unit ideal for hobby, service, automotive and development purposes. Because of its exceptional value for money, the Personal Scope is well suited for educational use.
Order Code: HPS10 - ~~£189.95~~ **£139.95**

See website for more super deals!

No.1 FOR KITS

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Everyday Practical Electronics
November 2012 Featured Kits

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested Down Under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

ARDUINO KITS

Arduino Experimenters Kit
Cat. XC-4262

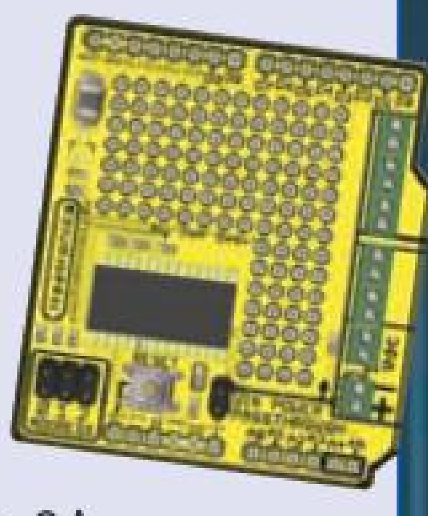
Servo motor, lights, buttons, switches, sound, sensors, breadboard, wires and more are included with a Freetronics Eleven Arduino compatible board in this extensive hobby experimenter and starter kit.

- Comprehensive instructions included
- Size: 340(W) x 165(H) x 36(D)mm

£32.75*

H-Bridge Motor Driver Shield for Arduino
Cat. XC-4264

Directly drive DC motors using your Arduino compatible board and this shield, which provides PWM (Pulse-Width Modulation) motor output on 2 H-bridge channels to let your board control the speed, direction and power of two motors independently.



- Suitable for 5, 12, or 24V motors up to 2A
- All outputs are diode and back-EMF protected
- Size: 60(W) x 54(H) x 12(D)mm

£11.00*

IR Temperature Sensor Module for Arduino
Cat. XC-4260

Connect this to your Arduino compatible board and point it at a surface or heat source to remotely measure its temperature.

- 3.3 to 5V operation
- -33 to +220°C measurement range, 1 second response time
- Size: 38(W) x 14(H) x 12(D)mm

£12.75*

128 x 128 Pixel OLED Display Module for Arduino
Cat. XC-4270

High resolution, full colour OLED display module! Perfect for graphics, gauges, graphs, even make your own video game or interactive display.

Full Colour OLED Display Module
128 x 128 Pixels
freetronics

- 16,384 full colour RGB pixels in a 128 x 128 format
- Active display area 28.8 x 26.8mm, (1.5" diagonal)
- Size: 44(W) x 36(H) x 5(D)mm

£18.25*

RGB LED Cube Kit for Arduino
Cat. XC-4274

This stunning 3D-matrix of 64 RGB LEDs connects directly to your Arduino-compatible board so you can produce mesmerising light shows controlled by software. Use it as a mood light or create your own "ambient device" that gently notifies you of new email or instant messages.

- 4 x 4 x 4 matrix of individually addressable 8mm RGB LEDs
- Arduino driver library with example programs
- Includes ZigBee headers so you can add a wireless module
- Size: 106(W) x 130(H) x 106(D)mm (assembled)

£32.75*

Solar Powered Shed Alarm Kit
Cat. KC-5494

Not just for sheds, but for any location where you want to keep undesirables out but don't have access to mains power e.g a boat on a mooring. It has 3 inputs so you can add extra sensors as required, plus all the normal entry/exit delay etc. Short form kit only - add your own solar panel, SLA battery, sensors and siren.

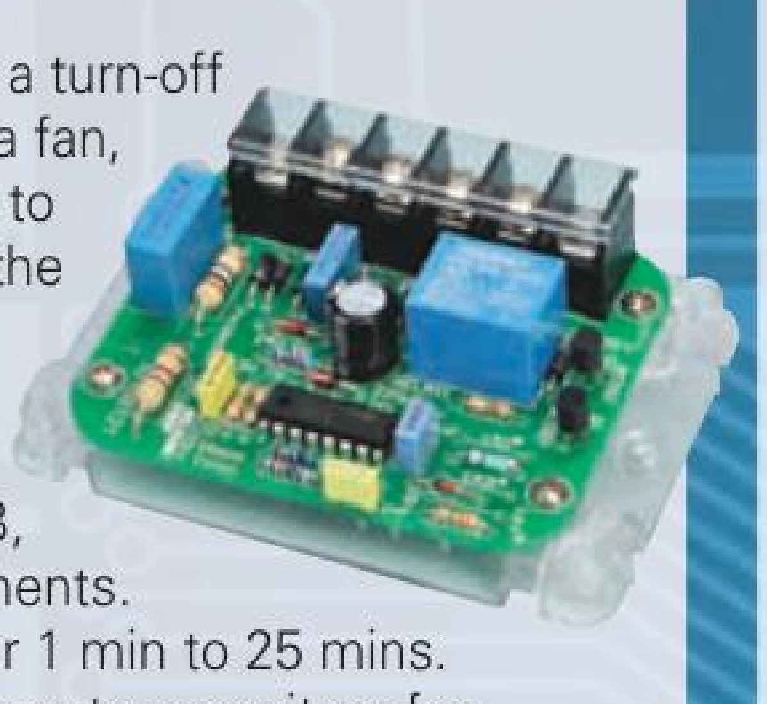
£11.00*

- Supply voltage: 12VDC
- Current: 3mA during exit delay; 500µA with standard PIR connected
- Alarm period: approximately 25 seconds to 2.5 minutes adjustable

Featured in EPE March 2012

Mains Timer Kit for Fans & Lights
Cat. KC-5512

This simple circuit provides a turn-off delay for a 230VAC light or a fan, such as a bathroom fan set to run for a short period after the switch has been tuned off. The circuit consumes no stand by power when load is off. Kit supplied with PCB, case and electronic components. Includes 100nF capacitor for 1 min to 25 mins. See website for a list of alternate capacitors for different time periods between 5 seconds to 1 hour.



- Handles loads up to 5A
- PCB: 60 x 76mm

£11.00*

Switching Regulator Kit
Cat. KC-5508

ALL SMD COMPONENTS PRE-SOLDERED ON BOARD

Outputs 1.2 to 20V from a higher voltage DC supply at currents up to 1.5A. It is small, efficient and with many features including a very low drop-out voltage, little heat generation, electronic shutdown, soft start, thermal, overload and short circuit protection. Kit supplied with PCB, pre-soldered surface mounted components.

- PCB: 49.5 x 34mm

£14.50*

Stereo Digital to Analogue Converter Kit
Cat. KC-5487

If you listen to CDs through a DVD player, you can get sound quality equal to the best high-end CD players with this DAC kit. It has one coaxial S/PDIF input and two TOSLINK inputs to which you can connect a DVD player, set-top box, DVR, computer or any other source of linear PCM digital audio. It also has stereo RCA outlets for connection to a home theatre or Hi-Fi amplifier. See website for full specifications.

£50.50*

- Short form kit with I/O, DAC and switch PCB and on-board components only.
- Requires: PSU **(KC-5418 £7.50)** and toroidal transformer **(MT-2086 £8.25)**

Featured in EPE November 2011

LED Battery Voltage Indicator Kit
Cat. KA-1778

This tiny circuit measures just 25mm x 25mm and will provide power indication and low voltage indication using a bi-colour LED, and can be used in just about any piece of battery operated equipment. Current consumption is only 3mA at 6V and 8mA at 10V and the circuit is suitable for equipment powered from about 6-30VDC. With a simple circuit change, the bi-colour LED will produce a red glow to indicate that the voltage has exceeded a preset value.

- PCB, bi-colour LED and all specified electronic components supplied
- PCB: 25 x 25mm

POPULAR KIT!

£3.75*

Regulated Voltage Adaptor Kit
Cat. KA-1797

A low-powered DC converter suited for many applications such as a peripheral computer power supply, powered speakers, modems, music/MIDI keyboards, etc. Just plug it's input into your PCs internal power supply cable and have selectable regulated voltage out from 3 to 15VDC. Output current capability is around 1.5 amps depending on the size of heatsink used (heat sink sold separately). PCB plus electronic components included.

- Input voltage MUST be larger than the required output voltage
- PCB: 52 x 19mm

£3.00*

ELECTRONIC PROJECTS FOR KIDS

Educational FM Radio Kit
Cat. KJ-8915

Allows kids to build their very own FM radio! No soldering required but requires the use of a long-nosed pliers and wire cutters (not included).

- Requires 2 x AA batteries
- Assembly time: 2 hours
- Recommended for ages 8+
- Size: 220(L) x 179(W) x 71(H)mm

£11.00*

12-in-1 Electrical Experiment Kit
Cat. KJ-8919

Contained within this kit are the parts to construct 12 different experiments demonstrating various practical electronic theories and principles such as static electricity, electric motors, the function of resistors/diodes, solar power and more. Included is a manual with excellent information describing the theory and history associated with each experiment.

- Requires 2 x AA batteries
- Recommended for ages 8+
- Base size: 120(L) x 99(W) x 23(H)mm

£9.25*

***All prices EXCLUDE postage & packing**

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POPULAR Kits for Electronic Enthusiasts

HOUSEHOLD KITS

Tempmaster Fridge Controller Kit Mk II

Cat. KC-5476

Turn an old chest freezer into an energy-efficient fridge or beer keg fridge. Or convert a standard fridge into a wine cooler. These are just two of the jobs this low-cost and easy-to-build electronic thermostat kit can do without the need to modify internal wiring! Used also to control 12V fridges or freezers, as well as heaters in hatcheries and fish tanks. Short-form kit contains PCB, sensor and all specified components. You'll need to add your own 240V GPO, switched IEC socket and case.

- PCB: 68 x 67mm

£12.00*

Temperature Switch Kit

Cat. KG-9140

This kit operates a relay when a preset temperature is exceeded and drops-out the relay when temperature drops. Ideal as a thermostat, ice alarm, or hydroponics applications, etc. Adjustable temperature range of approx -30 to +150 degrees Celsius. Kit includes NTC thermocouple. 12VDC required.

£9.25*

- PCB: 56 x 28mm

433MHz Remote Switch Kit

Cat. KC-5473

The receiver has momentary or toggle output and the momentary period can be adjusted. Up to five receivers can be used in the same vicinity. Short-form kit contains two PCBs and all specified components.

- 200m range
- PCB: Tx: 85 x 63mm
  Rx: 79 x 48mm

£16.50*

miniMaximite Controller Kit

£18.25*

Cat. KC-5505

A versatile and intelligent controller to interface with your creations, such as home automation. Features 20 configurable digital/analog I/O ports, 128K RAM and 256KB flash memory to hold your program and data. Design and test in MMBasic over a USB link from your PC, then disconnect the PC and the programs continue to operate. Alternatively, hard wire a PC monitor, keyboard, SD card reader and amplified speaker to work independent of a PC.

- Requires 2.3 - 3.6VDC (2 x AA or use plugpack **MP-3310 £7.00**)
- Kit supplied with PCB, pre-programmed and pre-soldered micro, and electronic components
- PCB: 78 x 38mm

ALL SMD COMPONENTS PRE-SOLDERED ON BOARD

CAN'T FIND THE KIT YOU ARE LOOKING FOR?

Our central warehouse keeps a quantity of older and slow-moving kits that can no longer be held in stores. A list of kits can be found on our website. Just search for "kit back catalogue".

Full Function Smart Card Reader / Programmer Kit

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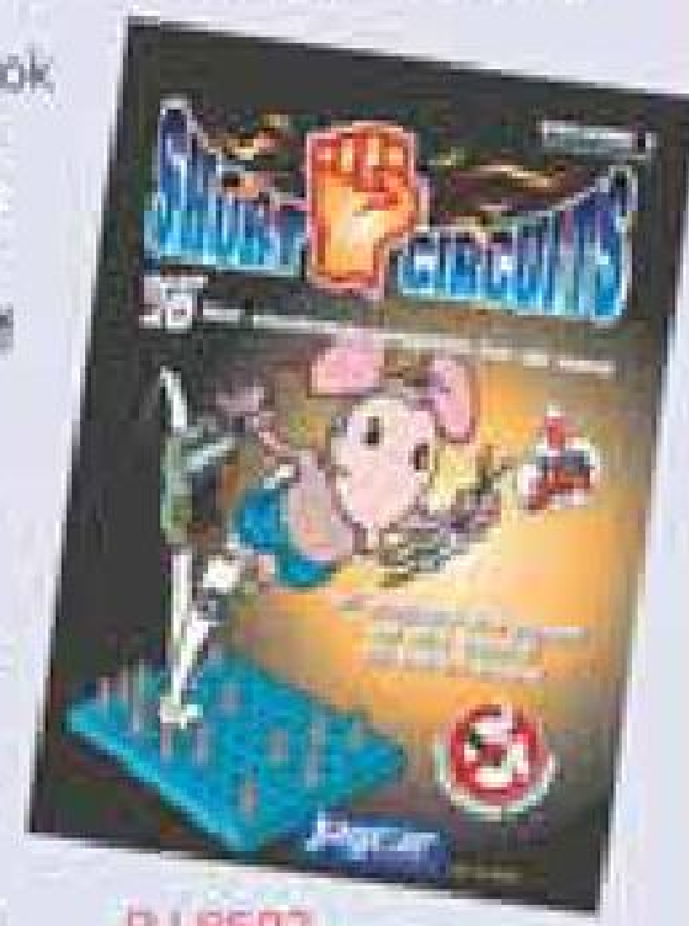

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EPE EVERYDAY PRACTICAL ELECTRONICS

Less is more

A popular song by the US rock star Bruce Springsteen is called *57 Channels (and nothin' on)*. It's basically a complaint that choice is no choice if all you are offered are things you don't want… I do know how he feels.

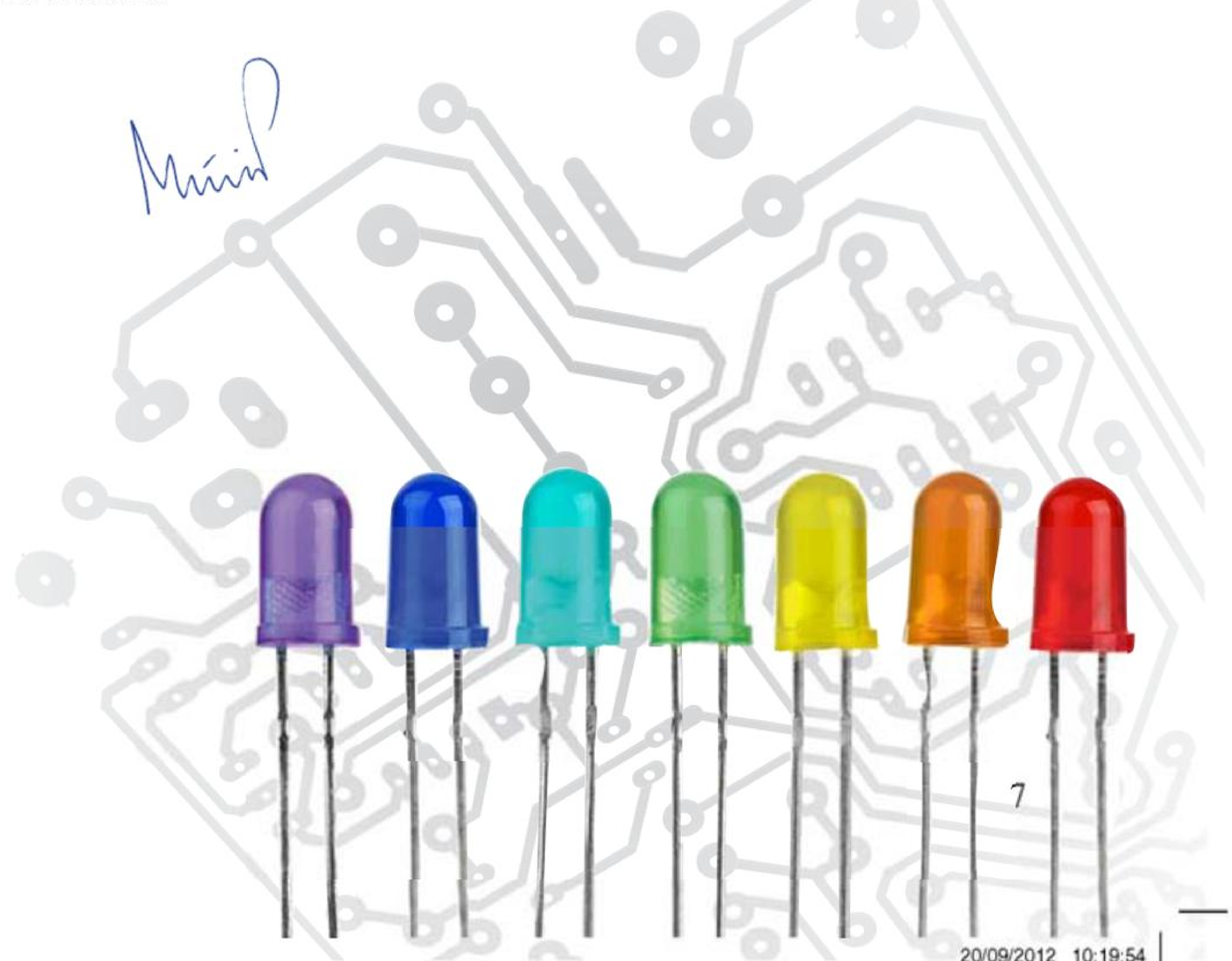
This particular line of thought was sparked by Barry Fox's excellent piece on the London Olympic video coverage in last month's *News* pages. After I first read his piece, I fired off a brief email to him saying: 'Personally, I'd much rather invest in higher definition than 3D, which I've always found to be annoying'. His response was: 'I have a 3D set and never watch in 3D.... Nor does anyone else I know…'

We have had 3D pushed at us in TV showrooms for several years now, and to be honest, I find the whole thing an irritating gimmick. It may be that children get a lot of amusement out of 3D cartoons, and perhaps I'm just being a visual dinosaur, but I would much rather spend money on more or simply better pixels instead of false 3D effects using cumbersome glasses that make my eyes tired and eventually give me headaches. I could watch (and enjoy) a clean, high resolution, flicker-free 2D screen till the cows come home, but if I try and buy a new TV these days almost all the so-called 'top-of-the-range sets' come with 3D. It feels as though I'm paying for technology I neither want nor will use. Worse still, there's a nagging doubt at the back of my mind that to shoehorn in extra capability, the things I really want may have been compromised.

It will be interesting to see if 3D is just a passing fad (something that has happened before with 3D cinema) or if it is here to stay. Personally, I can't wait to see the very high definition technology the BBC and Japan's NHK showcased at the Olympics – Super Hi-Vision. I just hope it won't end up being compromised as SHV-3D. This may not merely be 'a hope', as Barry Fox explains in this month's news piece. He notes that at the recent launch of the *Future of Innovation in Television Technology Taskforce* in London by the UK's Digital Television Group: 'Notably, there was no demonstration of 3D and no mention of 3D in any of the presentation speeches.'

Pi tomorrow…

Ooops… we did promise you more *Raspberry Pi* and *PIC n' Mix* delights this month, but unfortunately Mike Hibbett is still juggling a number of important commitments. However, we do hope to persuade Mike to return next month.



NEWS

A roundup of the latest Everyday News from the world of electronics

The next steps for television – report by Barry Fox

Each year, the *IFA* consumer electronics show in Berlin near-clashes with the professional *IBC* broadcast show in Amsterdam. Usually this does not matter much because the attendee lists are different. But this year, the conflict had consequences. Prototypes of 8k/4k (7680 × 4320 pixel resolution) Super Hi-Vision TV, as used by the BBC and NHK to shoot the London Olympics, are still in such short supply that demonstrators had to choose between shows. IBC won out because 8k/4k will initially be a capture format with home display in 4k/2k Quad HD (3840 × 2160).

4k/2k for Christmas

The first consumer Quad HD sets were shown at IFA, with Sony offering an 84-inch 4k/2k TV (panel made by LG) in time for Christmas. At the asking price of €25,000 it is hardly a mass-market product, but it does clearly signpost what is coming next.

Meanwhile, in London, the UK's Digital Television Group (DTG) launched its 'Future of Innovation in Television Technology Taskforce' in London – and also predicted that the next big thing after HD is likely to be Super Hi-Vision.

'There's an alignment of the planets. By the time we get the next World Cup in June 2014, we could be looking at Super Hi-Vision 4k in some way or other', predicted Richard Lindsay-Davies, director general of the DTG. He was speaking in London – with a live video link to IBC in Amsterdam – at the official launch of the Taskforce, by the UK government's Minister for Culture, Communications and Creative Industries, Ed Vaizey.

Said Ed Vaizey: 'The UK has a long list of world firsts in television areas as diverse as information services like teletext, interactive TV like the red button, and on-demand services like BBC iPlayer. We should capitalise on our strengths in innovation and not try to be a China or South Korea'.

DTG promotes UK content

The DTG controls digital and connected Internet protocol television (IPTV) in the UK, with standards and testing based on Europe's DVB and HbbTV technology. The new Taskforce pledges to showcase UK leadership in television technology innovation. A group of ten experts and thought leaders drawn from the content and technology sectors will work with specialist working groups to 'define the measures that should be implemented to leverage the UK's track record of innovating in television technology.' The Taskforce's findings and proposed solutions will be presented at the 2013 DTG summit.

Sony's €25,000 4K LCD screen contains over eight million individual pixels (3,840 x 2,160). You'll need an 84-inch sock if Santa brings you one for Christmas

The launch was held at the DTG's new HQ by the Thames (next door to the fortress which houses the UK's MI5 and MI6 security services) and featured working demonstrations of all the major box solutions now available in the UK for seamlessly blending off-air TV with broadband IPTV for catchup and video on demand (VOD) viewing.

Also on show was the PowerVR chip architecture from UK company Imagination Technologies, which has been licensed to Intel and lets a home PC easily handle 4k video or three simultaneous and different Blu-ray streams; and a 55-inch 4k (3840 × 2160) display from Toshiba labelled Ultra High Definition TV and screening demonstration footage.

HD or 3D?

Notably, there was no demonstration of 3D and no mention of 3D in any of the presentation speeches.

Richard Lindsay-Davies urged everyone present to look at the 4k demonstration, saying: 'There are two issues with 4k/8k – network capacity and processing speed. Capacity will be dealt with by new codecs. The new High Efficiency Video Coding (HEVC) (currently being developed by the ISO/IEC Moving Picture Experts Group (MPEG) and ITU-T Video Coding Experts Group (VCEG)) to double H.264 compression ratios for resolutions up to 7680 × 4320) should be ready by 2014.

'The cost of high processing speed is falling, as shown by Imagination's PowerVR. And historically big sporting events are milestones for technical change. Everything is heading our way for 4k to reach the market by 2013/14, although probably first for large screens in clubs and pubs.'

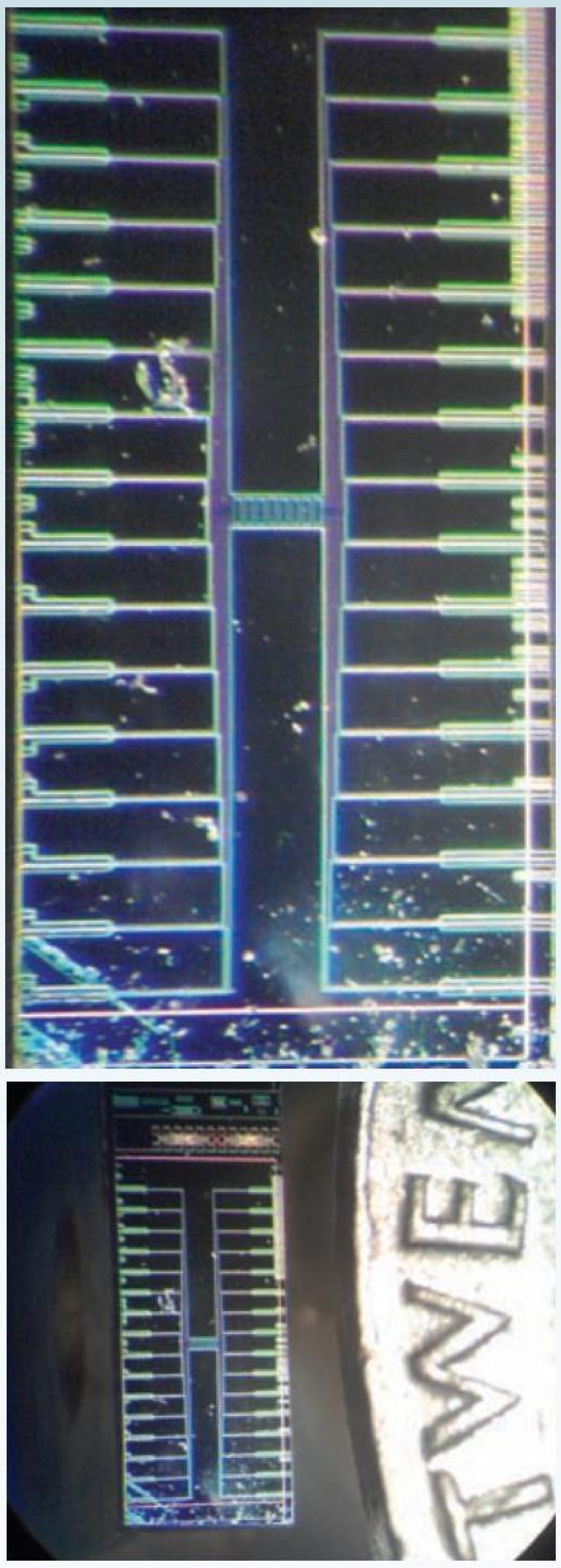
Although tactful and circumspect, Lindsay-Davies clearly has more confidence in 4k and 8k than 3D. 'I always feel increased resolution brings its own feeling of depth' he says. 'Also, with 4k or 8k resolution, a frame rate of 60Hz may not be enough. It can make the pictures look more like film. So I suspect we may need to adopt a higher rate. But that is the kind of thing the Taskforce will be looking at.'

Silicon quantum technology

At the launch of the *British Science Festival 2012*, scientists from Bristol University's Centre for Quantum Photonics announced the development of a silicon chip that will pave the way to mass-manufacture of miniature quantum chips.

The leap from glass-based circuits to silicon-based circuits is significant because fabricating quantum circuits in silicon has the major advantage of being compatible with modern microelectronics. Ultimately, this technology could be integrated with conventional microelectronic circuits, and could one day allow the development of hybrid conventional/quantum microprocessors.

In the short term, the team expect to apply their new results immediately for developing quantum-secure communications chips that could find their way into mobile phones and laptop computers – increasing the security of online banking and internet shopping. The very nature of quantum mechanics means phones using these quantum chips would have completely secure encryption – the phones would be 'unhackable'.


Top: the Bristol quantum silicon chip Below: the same chip next to a 20 pence coin for scale

Quantum leap

The Bristol-led team has taken the novel leap forward of developing quantum chips from silicon – the material routinely used *en masse* to manufacture conventional ICs in computers and smart phones. However, unlike conventional silicon chips that work by controlling electrical current, these circuits manipulate single particles of light (photons) to perform calculations.

These circuits exploit strange quantum mechanical effects, such as superposition (the ability for a particle to be in two places at once) and entanglement (strong correlations between particles that would be nonsensical in our everyday world). The new technology uses the same techniques as conventional microelectronics, and so can be economically scaled for mass-manufacture.

'Using silicon to manipulate light, we have made circuits over 1000 times smaller and more complex than current glass-based technologies. For the first time, we can mass-produce this kind of chip, and the much smaller size means it can be incorporated into technology and devices that would not previously have been compatible with glass chips' says Mark Thompson, deputy director of the Centre for Quantum Photonics. 'This is very much the start of a new field of quantum-engineering, where state-of-the-art microchip manufacturing techniques are used to develop new quantum technologies and will eventually realise quantum computers that will help us understand the most complex scientific problems.'

Quantum computer

The researchers also believe that their device represents a new route to a quantum computer – a powerful type of computer that uses quantum bits (qubits), rather than the conventional bits used in today's computers. This work, carried out in collaboration with Heriot-Watt University in Scotland and Delft University in the Netherlands, is an essential step towards the miniaturisations of optical quantum computers.

Unlike conventional digital bits or transistors, which can be in one of only two states at any one time (1 or 0), qubits can be in several states at the same time – they can hold and process a much larger amount of information at a greater rate.

'It had previously been thought that a large-scale quantum computer will not become a reality for at least another 25 years,' says Jeremy O'Brien, director of the Centre for Quantum Photonics. 'However, we believe that, using our new technology, such a device, in less than 10 years, will be performing important calculations that are outside the capabilities of conventional computers.'

Intel's UK investment

US IC giant Intel has announced the launch of the Intel Collaborative Research Institute for Sustainable Connected Cities in partnership with two of the world's leading universities, Imperial College London and University College London.

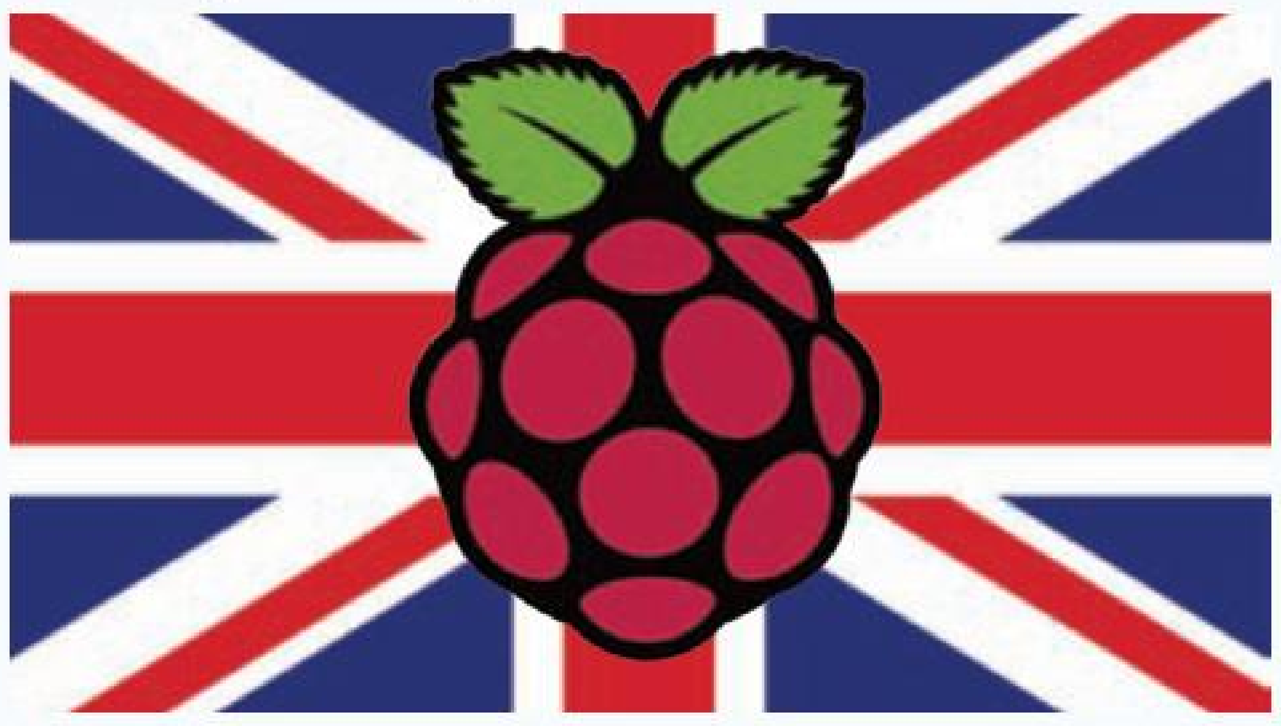
The new London-based institute will be Intel's first research centre and global hub dedicated to exploring how technology can support and sustain the social and economic development of cities worldwide. It will also collaborate with the emerging Tech City cluster in East London, using the social media expertise of Tech City-based start-ups to identify and analyse emerging trends within cities.

Internet address limit

It was bound to happen – and sooner rather than later – Europe is running out of old-style IPv4 Internet adresses. The system used, called IPv4, was created in the 1970s when it was assumed that the 4.3 billion permutations would easily be enough. However, this assumption failed to take account of the vast number of computers and other devices that now connect to the Internet, each of which needs its own unique address.

Plans are now being readied to move to the next system, called IPv6, which effectively has an infinite number of addresses.

Raspberry Pi – made in UK



Good news for patriotic British Raspberry Pi users. The credit card-sized single-board computer, which was developed in Cambridge is now going to be made in the UK.

Pi distributor Premier Farnell has struck a deal with the Sony UK Technology Center (Pencoed, Wales), to make a run of 300,000 devices.

Premier Farnell has been selling the Raspberry Pi since February 2012, but so far all the boards have been made in China.

(0dB = 0.1A/m)
+6dB
+3dB
0dB
-3dB
-6dB
-9dB
-12dB
-15dB
-18dB
-21dB
Hearing Loop Tester
T

HEARING LOOP Level Meter

Setting the correct signal level and minimising noise are critical factors when setting up a hearing loop. This easy-to-build tester can display field strength levels over a 27dB range. Here's how it works, how to build it and how to use it.

Part 1: By JOHN CLARKE

When installing a hearing aid loop, it is important to set the magnetic field strength to the correct level. This ensures that a hearing aid with a Telecoil (or T-coil) will deliver the best signal-to-noise ratio without signal overload.

The same applies if you are using a hearing loop receiver, such as the one described in the September 2012 issue of *EPE* (or a commercial equivalent).

Additionally, when setting up a hearing aid loop, it is important to verify that any background magnetic noise is at an acceptable level. Both background noise and signal strength from the hearing aid loop can be measured with this *Hearing Loop Tester*.

Specifications

Power supply: 9V at 18mA to 26mA

Display: –21dB to +6dB in 3dB steps

Meter response: 'S' (slow) response of 1s

Weighting: A-weighting or wide (see Fig.4)

Of course, if you are setting up a small hearing loop in your home, you can usually get away without using a level meter. In that case, it's usually just a matter of setting the level to give good results from the hearing aid without any overload occurring.

However, for a system that will be used by more than one person or the general public, it is important for the level to be correct. That way, the loop will be suitable for all who use it.

Main features

As shown in the photos, the *Hearing Loop Level Meter* is housed in a small hand-held plastic case that includes a battery compartment. A power switch and an indicator LED are located on the top panel, while the front panel carries 10 LEDs arranged in a vertical 'bargraph' column on the left-hand side.

In operation, this bargraph displays signal levels ranging from –21dB to +6dB, with each LED representing a 3dB step. However, to conserve battery life, the display is normally set to dot mode, which means that only one display LED is lit at any time. The current consumption is 18mA when no bargraph LEDs are lit and 26mA when one LED is lit. This is quite satisfactory for an instrument that is normally only used for short durations.

Alternatively, you can install a link under the PC board to convert to a conventional bargraph display. This is not recommended though, due to the increased current drain.

An important feature is that the unit can be accurately calibrated to indicate 0dB at a field strength of 100mA/m. This specification is based on the Australian Standard AS60118.4-2007 – 'Hearing Aids: Magnetic Field Strength In Audio-Frequency Induction Loops For Hearing Aid Purposes'.

Once calibrated, the meter can then be used to set the field strength level in a hearing loop to the correct level. It can also be used to measure the environmental background noise, to determine whether this is low enough for a hearing loop to be successful.

In operation, the unit is simply held at right-angles to the plane of the hearing loop for both signal level and noise measurements (see Fig.1 and Fig.2.).

Circuit details

Referring now to the complete circuit diagram for the *Hearing Loop Level Meter*, shown in Fig.3. It will be seen that it is based on four low-cost ICs, an inductor (L1), 11 LEDs and a handful of minor parts.

Inductor L1 is used to detect the magnetic field from the hearing loop. This inductor is actually a xenon flash-tube trigger transformer (Jaycar MM-2520) which has a high inductance, suitable for loop monitoring.

In this circuit, we use only the secondary winding of L1, which is wound as an autotransformer. This winding has an inductance of about 8.2mH and is biased at about 4.15V using two 10kΩ resistors connected in series across the 8.3V supply. A 100µF capacitor bypasses the divider output.

The 4.15V half-supply rail is also used to bias pin 5 of op amp stage IC1b (via L1). This allows IC1b's pin 7 output to swing symmetrically about this half-supply rail.

Coil L1's resistance is 27Ω and, in conjunction with the 100µF bypass capacitor, it presents a low source impedance to IC1b's pin 5 input at low frequencies. This minimises any low-frequency noise. The inductor's impedance increases with increasing frequency, but this is restricted by a parallel 2.2kΩ resistor.

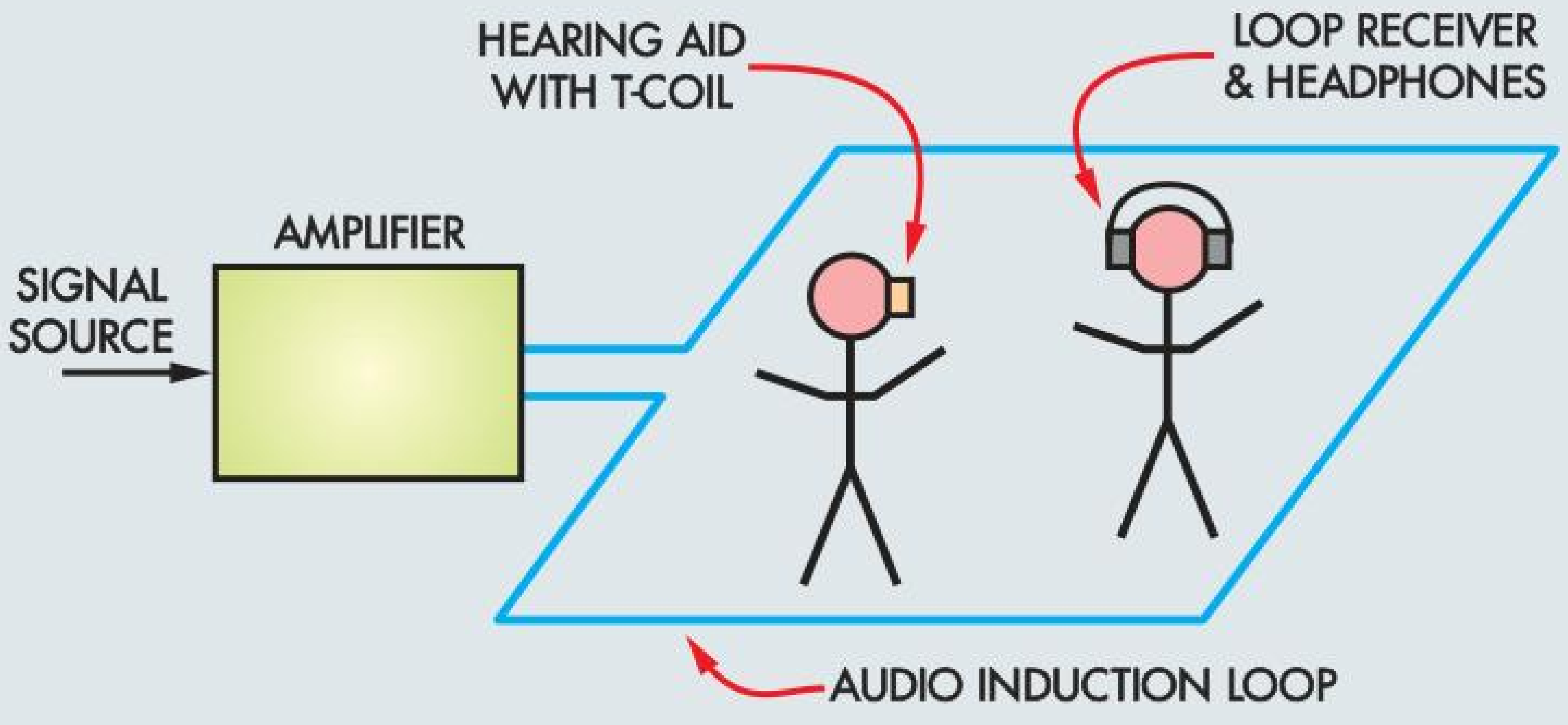
This 2.2kΩ resistor lowers the Q of the inductor, thereby preventing oscillation. A 220pF capacitor at the output of L1 also shunts any high-frequency signals to ground.

Signal level

Op amp IC1b is configured as a non-inverting amplifier stage with a nominal gain of 1001, as set by the 100kΩ and 100Ω feedback resistors. However, one aspect of using an inductor to receive the hearing loop signal is that the signal induced in L1 rises in level with frequency. This is because the induced voltage is proportional to the rate of change of the magnetic field.

As a result, IC1b's gain is reduced with frequency in order to achieve a flat overall frequency response. This is achieved by using a 33nF feedback capacitor and a 100kΩ feedback resistor to roll off signal frequencies above about 50Hz by 20dB per decade. This counteracts the 20dB per decade increase from the inductor.

Fig.1: the basic arrangement for a hearing loop. The loop creates a varying magnetic field in response to the driving signal and this is picked up by suitably-equipped hearing aids and receivers.



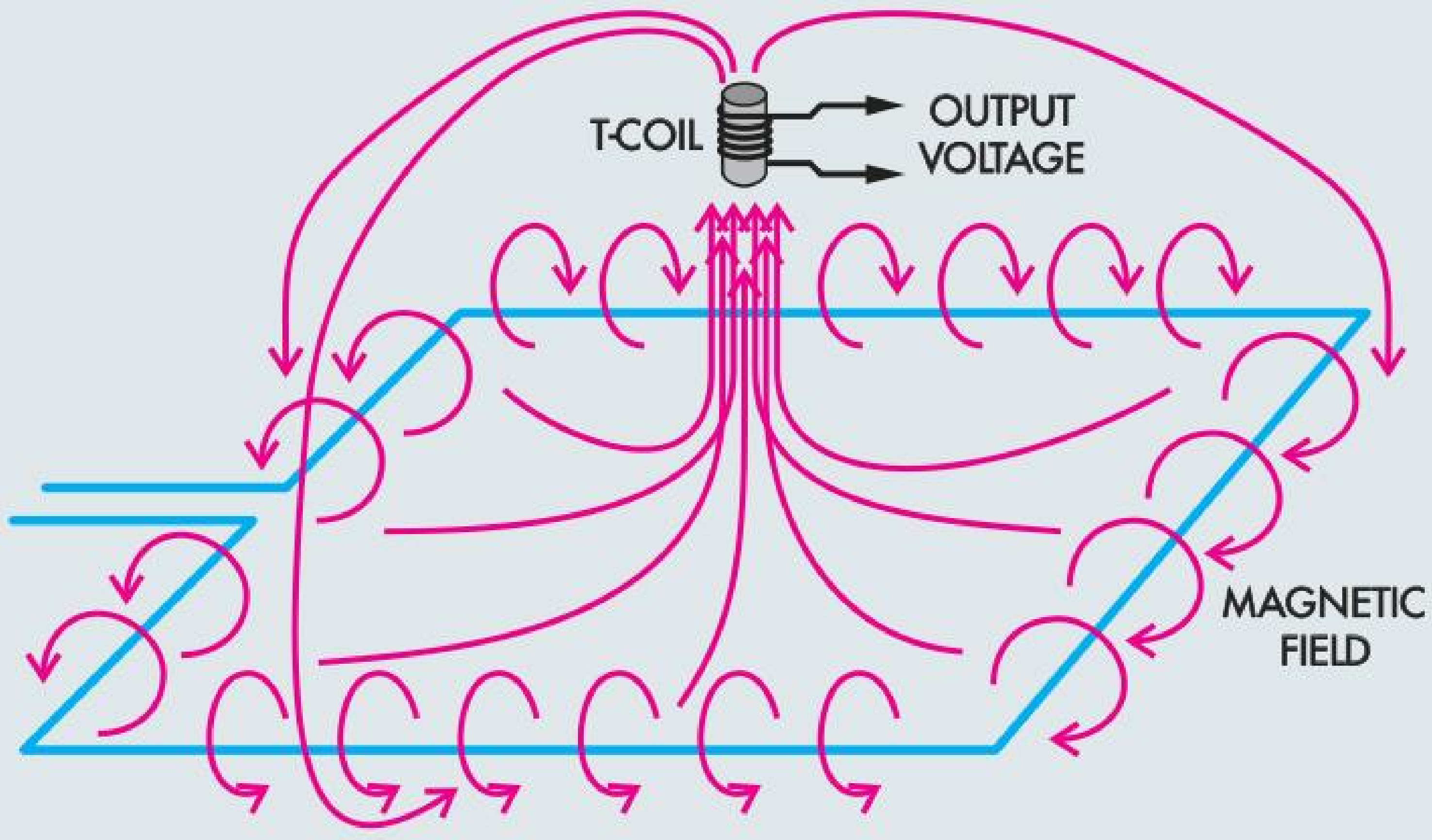


Fig.2: this diagram illustrates the magnetic field generated by the hearing loop and shows how it couples into a hearing-aid T-coil.

In addition, IC1b's low-frequency gain is rolled off below 723Hz using a 100Ω resistor and 2.2µF capacitor connected in series between pin 6 (the inverting input) and ground (0V). If link LK1 is installed, an extra 22µF capacitor is placed across the 2.2µF capacitor and this lowers the low-frequency roll-off point to around 66Hz.

Op amp IC1a provides a further stage of gain. If trimpot VR1 is set to its minimum, IC1a's gain is 1+ (100kΩ/150Ω) or about 667. However, if VR1 is set to its maximum value of 5kΩ, the gain is reduced to about 20. This range of gain adjustment allows the meter to be calibrated.

IC1a's high-frequency roll-off starts at about 10.6kHz, due to the 100kΩ resistor and 150pF capacitor in the feedback path. In addition, both IC1b and IC1a have inherent reduced gain at high frequencies. IC1a's low frequency roll-off depends on the setting of trimpot VR1 and occurs somewhere between 10.6Hz and 0.32Hz.

A-weighting

The high and low roll-off frequencies set for IC1b, with LK1 out of circuit, produce a nominal A-weighted overall frequency response for the level metering. A-weighting is a tailored response that's designed to match the way our ears perceive loudness with respect to frequency at a particular low-level sound pressure. The weighting rolls off the signal below and above 1kHz, as shown in the graph of Fig.4.

Inserting link LK1 extends the frequency response of the unit down to at least 200Hz, before rolling it off at the lower frequencies. As explained later, this wider response is better for checking background noise levels than the A-weighted curve. **As a result, we recommend that LK1 be installed for all measurements (including loop level measurements), to provide a nominal frequency response of 200Hz to 10kHz (–3dB points).**

In fact, the relatively flat response of the meter between 200Hz and 5kHz with LK1 in is ideal for checking hearing loop response levels. If necessary, treble boost can be applied to the loop amplifier to counter the effect of drooping high-frequency response due to the loop inductance.

Precision rectifier

IC1a's output (pin 1) is fed via a 100nF capacitor to a full-wave precision rectifier stage based on IC2b, IC2a and

Parts List – Hearing Loop Level Meter

- 1 PC board, code 874, available from the *EPE PCB Service*, size 65mm × 86mm
- 1 remote control case, 135mm × 70mm × 24mm (Jaycar HB5610 or equivalent)
- 1 miniature PC mount SPDT toggle switch (S1)
- 3 8-pin IC sockets (optional)
- 1 18-pin IC socket (optional)
- 1 xenon flash tube trigger transformer (Jaycar MM2520 or equivalent) (L1)
- 1 2-way pin header (2.54mm spacing)
- 1 jumper shunt for pin header
- 4 M3 × 5mm screws
- 1 9V (216) alkaline battery
- 1 9V battery clip
- 1 40mm length of 0.7mm tinned copper wire
- 2 PC stakes
- 1 panel label, 55mm × 14mm
- 1 panel label, 113mm × 46mm

Semiconductors

- 2 TL072 dual op amps (IC1,IC2)
- 1 LM3915 log bargraph driver (IC3)
- 1 7555 CMOS timer (IC4)
- 1 1N5819 1A Schottky diode (D1)
- 4 1N4148 diodes (D2-D5)
- 1 3mm red LED (LED1)
- 2 3mm orange LEDs (LED2,LED3)
- 8 3mm green LEDs (LED4-LED11)

Capacitors

- 1 470µF 16V radial electrolytic
- 4 100µF 16V radial electrolytic
- 1 22µF 16V radial electrolytic
- 3 10µF 16V radial electrolytic
- 1 2.2µF 16V radial electrolytic
- 1 1µF 16V radial electrolytic
- 1 100nF MKT polyester
- 1 33nF MKT polyester
- 1 1nF MKT polyester
- 1 220pF ceramic
- 1 150pF ceramic
- 1 10pF ceramic

Resistors (0.25W, 1%)

- 1 1MΩ
- 1 300kΩ
- 1 150kΩ
- 2 100kΩ
- 2 15kΩ
- 4 10kΩ
- 3 2.2kΩ
- 2 150Ω
- 1 100Ω
- 1 10Ω
- 1 5kΩ horizontal trimpot (code 502) (VR1)

Helmholtz coil (next month)

- 2 836mm lengths of 2.4mm diameter steel fencing wire (or similar stiff wire)
- 1 piece of timber, approximately 65mm × 19mm × 200mm
- 1 33Ω 0.25W resistor
- 1 wire clamp made from two solder lugs or metal scrap
- 4 small rubber feet (optional)
- 1 400mm length of medium-duty hook-up wire
- 1 1m length of shielded cable
- 1 3.5mm stereo jack line plug
- 4 solder lugs
- 3 small wood screws

diodes D4 and D5. The capacitor rolls off the response below about 106Hz. This stage works as follows.

When the signal from the 100nF capacitor swings positive, pin 7 of IC2b goes low and forward biases diode D4. As a result, IC2b operates as an inverting amplifier stage with a gain of –1, as set by the 15kΩ input and 15kΩ feedback resistors on its pin 6.

This inverted signal at D4's anode is applied to IC2a's inverting input (pin 2) via a 150kΩ resistor. This stage operates with a gain of –6.66, as set by the ratio of the 1MΩ feedback resistor and the 150kΩ input resistor. As a result, the total gain for the signal path from pin 1 of IC1a to pin 1 of IC2a via IC2b is (–1) × (–6.66) = +6.66.

In addition, the positive-going signal from IC1a is applied to IC2a via a second signal path, ie, via a 300kΩ resistor. For this path, IC2a operates with a gain of –3.33 and so the overall signal gain from the output of IC1a to the output of IC2a is +6.66 – 3.33 = +3.33.

Now consider what happens for negative-going signals from IC1a. In this case, diode D5 is forward biased and so IC2b's output is clamped at about 0.6V above its pin 6 input. As a result, no signal flows via D4 and IC2b ceases operating as an inverting amplifier.

This means that negative-going signals from IC1a are fed to IC2a via the 300kΩ resistor only (ie, via only one signal path). Because IC2a operates with a gain of –3.33 for this path, the signal is inverted. Therefore, the precision rectifier provides a positive output for both positive-going and negative-going signals from IC1a, and both have a gain of 3.33.

IC2a also provides low-pass filtering of the signal so that its response is slow to incoming signal level changes. The time constant is around one second (1s) as set by the 1MΩ feedback resistor and its parallel 1µF capacitor. This matches the slow (S) response requirement for measuring background noise for a hearing loop system.

Bargraph circuit

IC2a's output is fed to input pin 5 of IC3, an LM3915 10-LED bargraph driver with a logarithmic response. The bargraph displays a 27dB range with each LED covering 3dB. We have labelled the display so that is covers field strength levels from +6dB down to –21dB

As explained previously, the unit is calibrated to read 0dB at a field strength of 100mA/m.

The voltage range for the meter display is from 1.25V at full scale (+6dB) down to about 56mV for the –21dB LED. This range is set by connecting the R_{HI} input (pin 6) to the 1.25V reference (pin 7) and the R_{LO} input (pin 4) to ground (0V). The 2.2kΩ resistor between REF (pin 7) and ground sets the bargraph LED current to about 6mA. Link LK2 sets the bargraph mode.

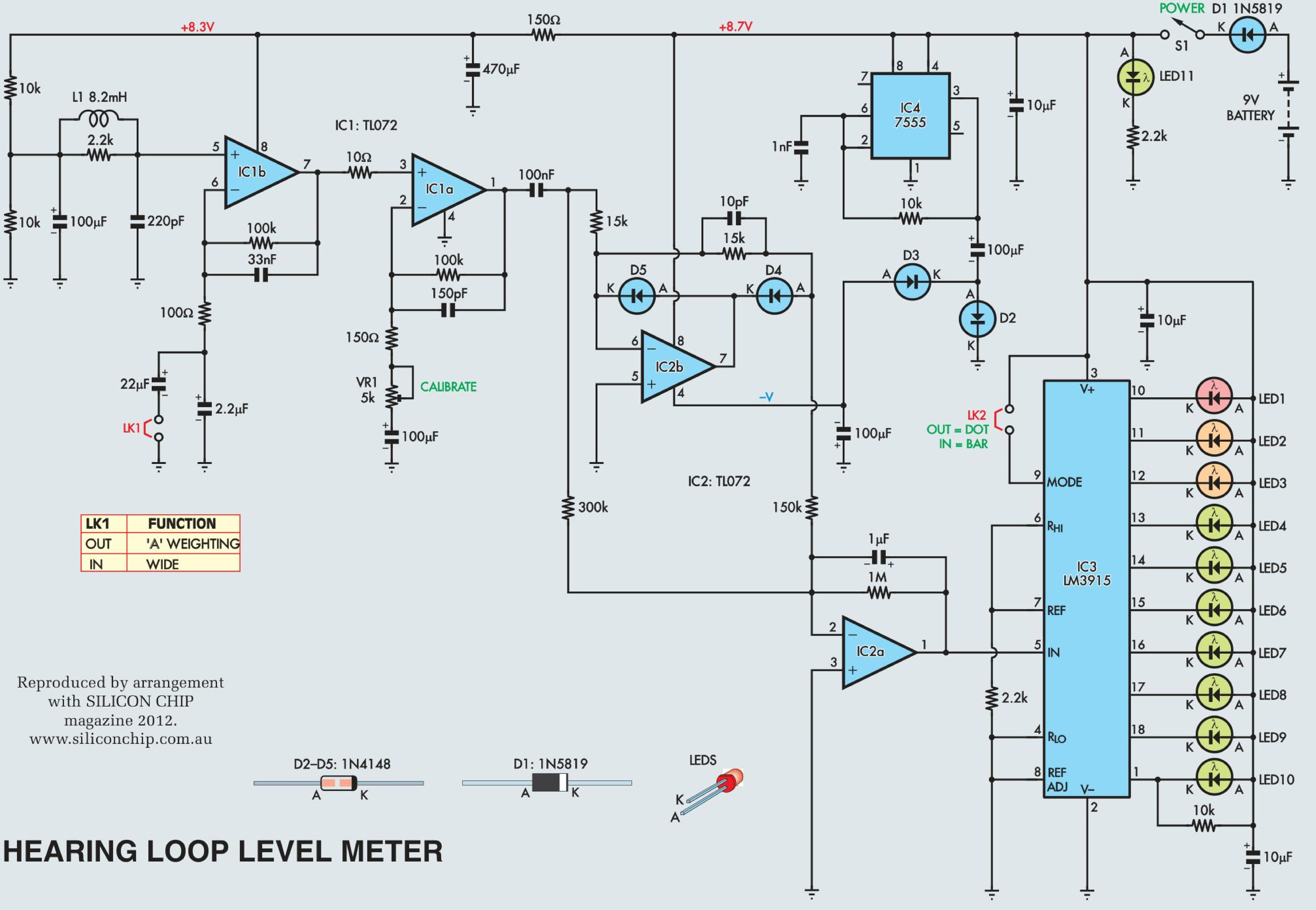
Power supply

Power for the circuit is derived from a 9V battery, with diode D1 providing reverse polarity protection. S1 functions as a power switch, while LED11 is used as a power-on indicator. The 2.2kΩ resistor in series with LED11 limits the current through it to about 3.5mA.

The resulting 8.7V rail is filtered using a 10µF capacitor and directly supplies IC2, IC3 and IC4. IC1's supply is also derived from this rail, but is decoupled using a 150Ω resistor and a 470µF filter capacitor. This is done so that supply variations, due to changes in the LED bargraph display, are not introduced into IC1, which contains two sensitive amplifier stages.

A negative supply for IC2 is generated using a 7555 timer, IC4, diodes D2 and D3 and two 100µF capacitors. IC4 is wired as an astable oscillator

HEARING LOOP LEVEL METER


+8.3V
150Ω
+8.7V
POWER
D1 1N5819
S1
9V BATTERY
LED11
2.2k
10k
L1 8.2mH
2.2k
100µF
220pF
IC1b
100k
33nF
100Ω
22µF
2.2µF
LK1
IC1: TL072
470µF
10Ω
IC1a
100k
150pF
150Ω
VR1 5k
CALIBRATE
100µF
100nF
15k
10pF
15k
D5
D4
IC2b
–V
300k
IC2: TL072
150k
1µF
1M
IC2a
IC4 7555
1nF
10k
100µF
D3
D2
100µF
10µF
10µF
LK2
OUT = DOT
IN = BAR
IC3 LM3915
V+
MODE
RHI
REF
IN
RLO
REF ADJ
V–
2.2k
LED1
LED2
LED3
LED4
LED5
LED6
LED7
LED8
LED9
LED10
10k
10µF
D2–D5: 1N4148
D1: 1N5819
LEDS
A
K

LK1	FUNCTION
OUT	'A' WEIGHTING
IN	WIDE

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Fig.3: the circuit uses inductor L1 to detect the magnetic field generated by the hearing loop. The resulting signal is then amplified by IC1b and IC1a and fed to a precision rectifier based on IC2b, IC2a and diodes D4 and D5. The output from the rectifier then drives IC3, which in turn drives the 10 LEDs in the bargraph display. Power comes from a 9V battery, while IC4 and diodes D2 and D3 generate a –7V rail for op amp IC2.

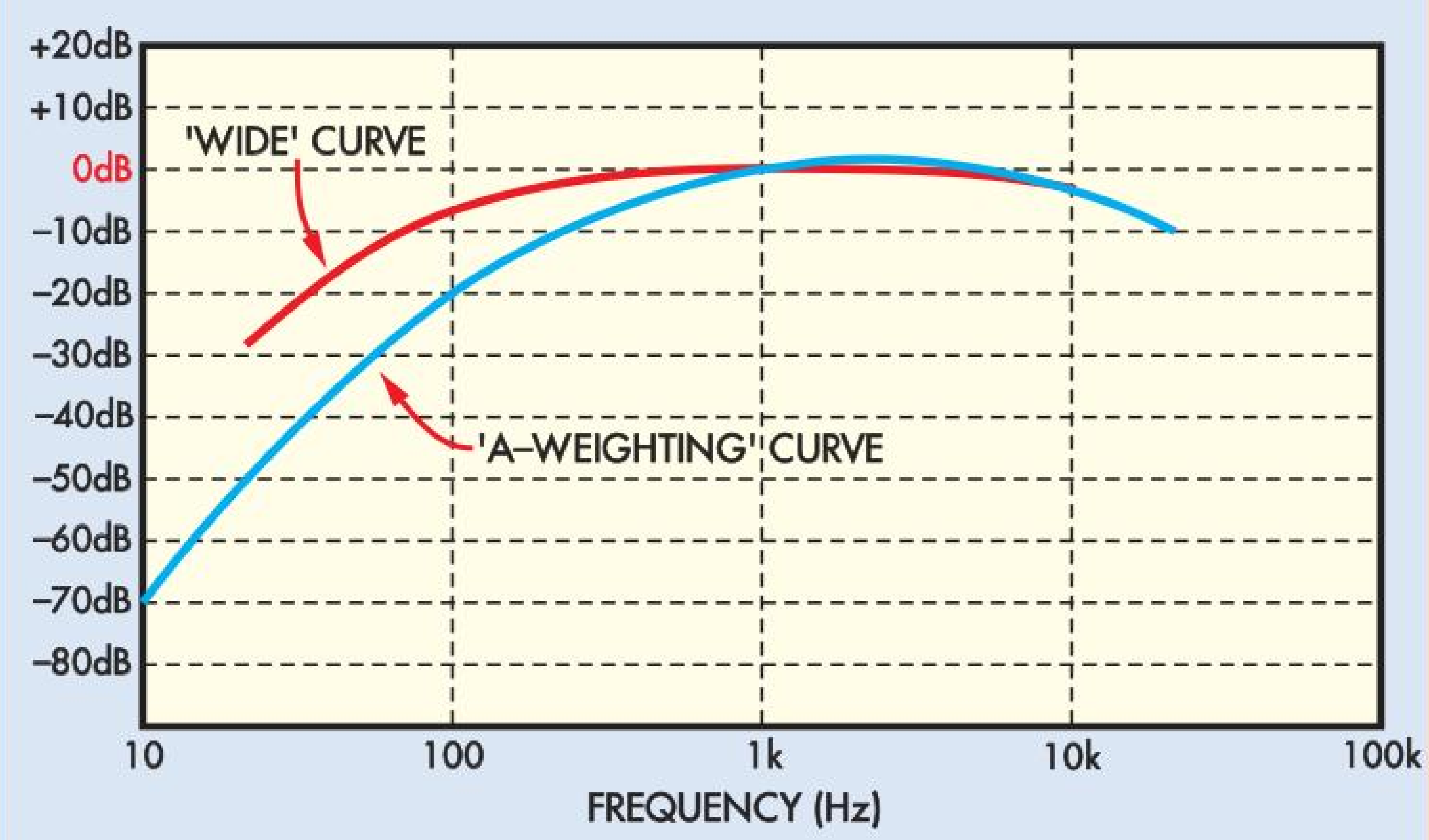


Fig.4: this graph shows the frequency response of the Loop Tester with LK1 installed (wide) and with LK1 removed (A-weighting).

and operates at about 72kHz due to the timing components on pin 6 and pin 2, ie, a 1nF capacitor to ground and a 10kΩ resistor which is connected back to pin 3.

It operates as follows: when power is first applied, IC4 pin 3 goes high and the 1nF capacitor charges via the 10kΩ resistor. When it reaches 2/3rds the supply voltage, the pin 3 output goes low and the capacitor discharges until it reaches 1/3rd the supply voltage. Pin 3 then switches high again and so the process repeats indefinitely while power is applied.

As well as charging/discharging the timing capacitor, pin 3 also drives the negative supply circuit. When pin 3 goes high, it charges its associated 100µF capacitor to the positive supply rail (+8.7V) via diode D2. Then, when pin 3 of IC4 subsequently switches low, the positive side of the 100µF capacitor is pulled to 0V. As a result, its negative side goes to –8.7V (or thereabouts) in order to maintain the charge across the capacitor.

This negative voltage now charges the second 100µF capacitor via diode D3 to provide the negative rail for IC2. The actual rail voltage obtained depends on the load and the voltage drops across the two diodes, but in practice, will be close to –7V.

Construction

All parts except for the battery are mounted on a single-sided PC board coded 874 (65mm × 86mm). This board is available from the *EPE PCB Service*. All parts are housed in a remote control case measuring 135mm × 70mm × 24mm. Two labels are attached to the front and top panels to give a professional finish – see photos.

The PC board is designed to mount on to the integral bushes inside the box. Check that the top edge of the PC board has the corner cutouts so that it fits correctly. If necessary, you can make the cutouts yourself using a small hacksaw and then carefully filing them to shape.

The component layout on the PC board is shown in Fig.5. Begin construction by carefully checking the board for any breaks in the copper tracks and for shorts between tracks and pads. The four mounting holes and the two holes that are used to anchor the battery clip leads should all be 3mm in diameter.

The assembly is best started by installing the two wire links and the resistors. Table 1 shows the resistor colour codes, but it's also a good idea to check each one using a digital multimeter (DMM).

Follow with the diodes, taking care to orient them as shown. Note that D4 and D5 face in opposite directions. That done, install two PC stakes to terminate the battery clip leads.

Next, install IC sockets for IC1 to IC4 with their notched ends facing in the directions shown in Fig.5 (note: IC3 faces the opposite way to the others). The ICs can then be fitted, taking care to ensure that IC4 is the 7555. Alternatively, you can solder the ICs straight in.

The 2-way header for LK1 can now go in, followed by the capacitors. Be sure to install the electrolytics the right way around and keep their heights above the PC board to less than 12.5mm, otherwise the lid of the case will not fit correctly. If necessary, sit the electrolytics up off the board slightly and then bend their bodies over after soldering.

Trimpot VR1, switch S1 and inductor L1 are next. Note that a third (thin) wire attached to L1 is soldered to a spare pad on the PC board.

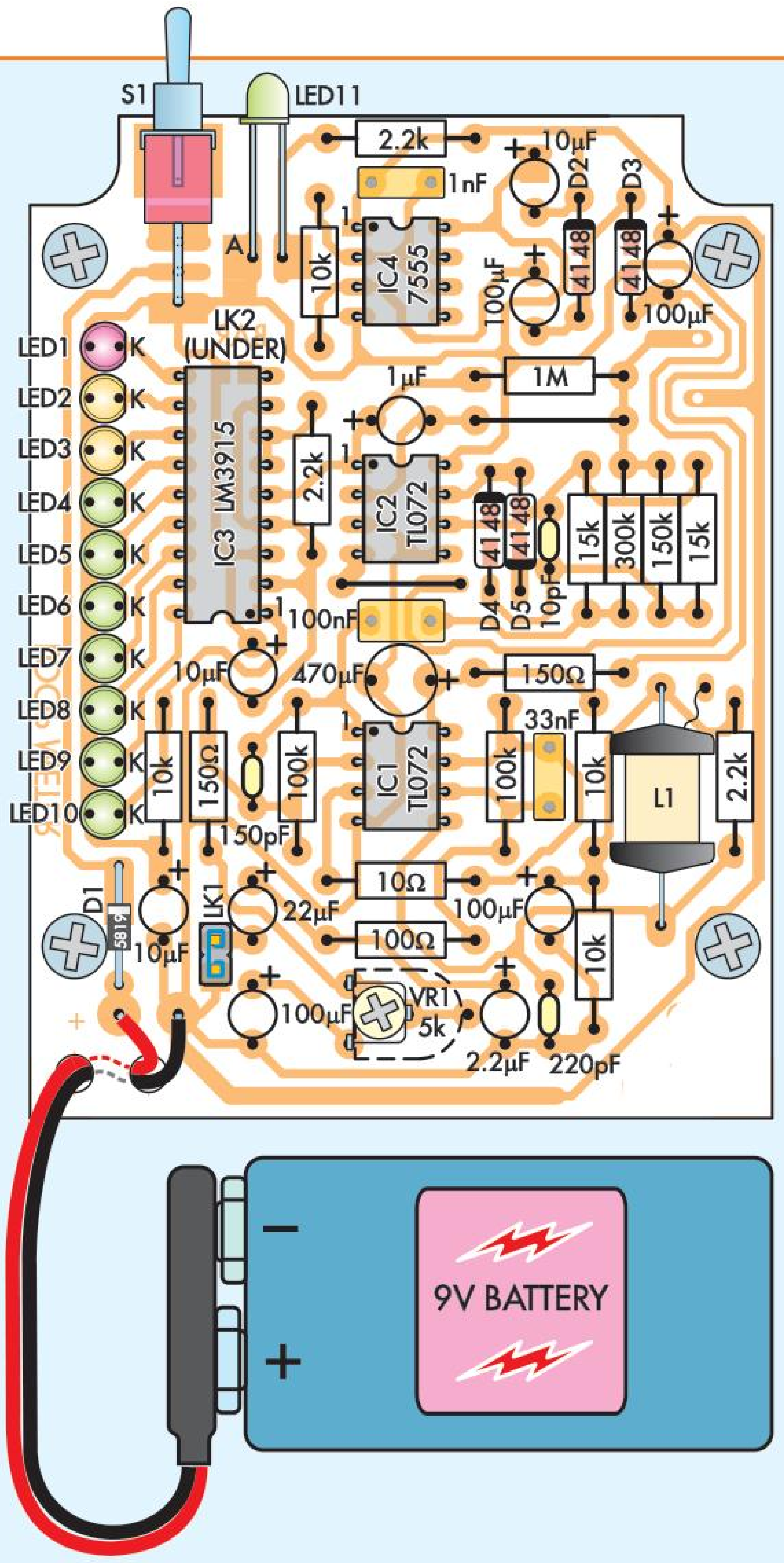
Installing the LEDs

LED1 to LED10 must be installed so that the top of each LED is exactly 15mm above the PC board. This can be done by cutting a 10mm-wide cardboard spacer which is slid between the leads during soldering. Take care with the orientation (the anode (A) is the longer of the two leads) and be sure to push each LED down on to the spacer before soldering it in place. Note also that LED1 is red, LED2 and LED3 are orange and LED4 to LED10 are green.

The power LED (LED11) is installed so that it sits horizontally with the centre of its lens 6mm above the board. To do this, cut a 6mm-wide cardboard spacer, then bend the LED's leads

Table 1: Resistor Colour Codes

☐	No.	Value	4-Band Code (1%)	5-Band Code (1%)
☐	1	1MΩ	brown black green brown	brown black black yellow brown
☐	1	300kΩ	orange black yellow brown	orange black black orange brown
☐	1	150kΩ	brown green yellow brown	brown green black orange brown
☐	2	100kΩ	brown black yellow brown	brown black black orange brown
☐	2	15kΩ	brown green orange brown	brown green black red brown
☐	4	10kΩ	brown black orange brown	brown black black red brown
☐	3	2.2kΩ	red red red brown	red red black brown brown
☐	2	150Ω	brown green brown brown	brown green black black brown
☐	1	100Ω	brown black brown brown	brown black black black brown
☐	1	10Ω	brown black black brown	brown black black gold brown


S1
LED11
2.2k
10µF
1nF
D2
D3
10k
IC4 7555
100µF
4148
4148
100µF
A
LK2 (UNDER)
LED1
LED2
LED3
LED4
LED5
LED6
LED7
LED8
LED9
LED10
K
IC3 LM3915
1µF
1M
2.2k
IC2 TL072
4148
4148
10pF
15k
300k
150k
15k
D4
D5
100nF
10µF
470µF
150Ω
33nF
10k
150Ω
100k
IC1 TL072
100k
10k
L1
2.2k
150pF
D1
5819
10µF
LK1
22µF
10Ω
100Ω
100µF
10k
100µF
VR1 5k
2.2µF
220pF
9V BATTERY
–
+

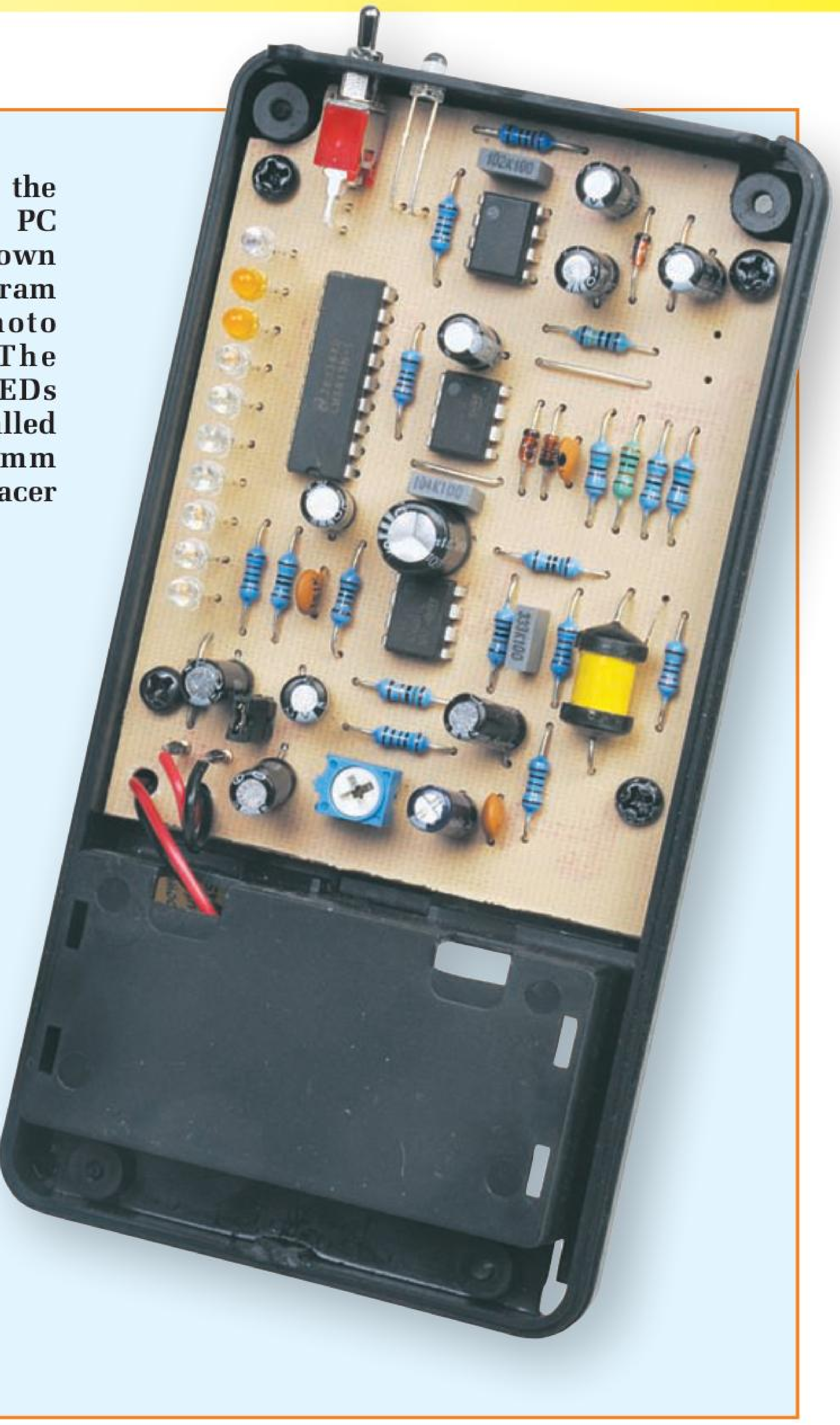


Fig.5: install the parts on the PC board as shown on this diagram and the photo at right. The bargraph LEDs must be installed using a 10mm cardboard spacer – see text.

down through 90° 12mm from its base, making sure that the anode lead is to the left. The leads can then be inserted into the PC board and pushed down on to the 6mm spacer before soldering.

Now for the battery clip. This is installed by first passing its leads through the battery compartment and then looping them through the holes in the PC board as shown. This anchors the leads, which can now be soldered to the PC stakes (watch the polarity).

The PC board can now be secured to the base of the case using four M3 × 5mm screws into the integral mounting bushes. That done, attach the label to the top panel and drill the clearance holes for the power switch and indicator LED.

If the label is not supplied as part of a kit, you can download the artwork in PDF format from the *EPE* website (**www.epemag.com**) in the Library section.

You will also need to drill ten 3mm diameter holes for the bargraph LEDs in the lid. These holes must line up along the inside border of the inset section on the top lid. Note that the label does not extend fully to the left side of this inset, so it does not need to be drilled.

If you are building this project from a kit, then the labels will probably be supplied. If not, the downloaded PDF files can be printed out on to photo paper, with a peel-away adhesive backing or on to clear plastic film. If using clear plastic film (eg, overhead projector film), you can print the label as a mirror image so that the ink is at the back of the film when it is placed on to the panel.

Wait until the ink is dry before cutting the label to size. The film can then be affixed in place using an even smear of neutral-cure silicone sealant. If you are affixing the label to a black coloured panel (eg, if using the specified case), use grey or white-coloured silicone so that the lettering will stand out.

The holes for the power switch and indicator LED in the top label can be cut out using a sharp hobby knife after the silicone has cured.

Testing

Before applying power, go back over your work and check for wiring errors. That done, connect a 9V battery, switch on and check that the power LED lights. If not, then either D1, LED11 or the battery is the wrong way around (or a combination of these).

Assuming the LED does light, check that pin 8 of IC1 is at about 8.3V (assuming that the battery itself measures 9V). Similarly, check that pin 8 of IC2 is at about 8.7V and that pin 4 is at about –7V. Pin 3 of IC3 should be at 8.7V, as should pin 8 of IC4.

If these supply voltages check out, touch the bottom lead of inductor L1. This should cause some of the LEDs in the bargraph to light due to the noise introduced into op amp IC1b. Note: it can take several seconds for the unit to display a bargraph reading immediately after switch-on.

That's all for this month. Next month, we'll give the calibration procedure and describe how the unit is used.

TechnoTalk

Happier motoring

Mark Nelson

Lower petrol prices would put a smile on most motorists' faces, but a good substitute would be harnessing the power of electronics to avoid traffic snarl-ups and avert accidents. Mark reviews what's going on in this direction.

NO DOUBT you are aware of Google Traffic Information, which displays current (live) and average traffic flows on Google maps, but have you ever wondered how this data is gathered?

If you have not yet discovered this gem, look in the top-right corner of the map for a rectangular button labelled TRAFFIC and tick this option. You will now see coloured overlays on major roads in the area showing the speed of traffic. Clicking on the word CHANGE at lower left allows you to see the usual traffic flows at various times and days, which will help you re-plan your journey to avoid congestion.

But how do they know?

Google buys traffic flow data from the UK Highways Agency, which back in 2008 was the first organisation in Europe to work with Google in this way. The information is captured from traffic flow monitoring equipment, automatic number plate recognition (ANPR) cameras, and intelligence from the police, local authorities and other organisations.

Traffic flow monitoring equipment includes solar-powered roadside traffic monitoring stations and MIDAS, which is the motorway incident detection automatic signalling system. There are 1,500 solar-powered traffic monitoring stations across England, which measure the average speed and flow of the traffic and send this data back to the NTOC at five-minute intervals.

Ways and means

The most commonly used means of capturing traffic flow data in the field involves inductive loops. An insulated, electrically conducting loop of wires is embedded in the roadway in grooves just below the surface. Such an installation is very easy to spot at traffic lights and other locations.

As Wikipedia helpfully explains, an electronics unit transmits energy into the wire loops at frequencies between 10kHz to 200kHz. The inductive-loop system behaves as a tuned circuit in which the loop wire and lead-in cable are the inductive elements.

When a vehicle passes over the loop or is stopped within the loop, the vehicle induces eddy currents in the wire loops, decreasing their inductance. This is detected by a relay or a solid-state optically isolated output, sending a pulse to the control box to indicate the passage or presence of a vehicle.

Although inductive loops are simple and generally reliable, the loops themselves can cause the road surface to crack and break up, while the 'tail' connections from the loop to the control box can suffer damage by careless construction or telecomms maintenance. In fact, if you use Google Maps to monitor traffic flows, you can see that the roads are divided into many small segments. Some of these segments have no speed colour coding, which may well indicate that the sensors within those sectors are defective.

Magnetometers make it work

In the latest installations, magnetometers are the preferred technology. The manufacturer Clearview Traffic explains how three magnetic detection sensors are used to measure the X, Y and Z axis of the earth's natural magnetic field. When no vehicles are present, the sensor will calibrate itself by measuring the values of the background magnetic field and thereby establish a reference value. The passage and presence of vehicles are detected by measuring deviations from that reference value.

Each sensor automatically self-calibrates to the specific installation site and to any long term variations of the local magnetic field by allowing this reference value to change over time. This ensures that operation accuracy is maintained, despite external factors such as movement of the sensor due to road surface wear and tear.

The magnetometer devices are buried in the roadway and measure just 74mm × 74mm × 49mm tall. Communication between these and the control box is by radio, employing extremely low-powered two-way radio communications developed at Berkeley University in San Francisco, providing the battery with an operational life in excess of ten years.

The roadside control box has wired or wireless IP connectivity (typically optical fibre or cellular radio) to send the data collected to the National Traffic Information Service. It is equipped with a solar panel for charging the batteries that power the electronics.

Active cat's eyes

While researching these technologies I discovered another ingenious development, 'active *cat's eyes*'. Whereas the glass reflectors of the old *cat's eyes* (reflective studs) patented by Percy Shaw in 1934 were purely passive, today's replacement is battery-powered and uses ultra-bright LEDs. They are ten times brighter and more effective than their glass counterparts and offer two additional colours (amber and blue) to the white, red and green available in glass.

Active *cat's eyes* offer many other advantages too. Glass reflectors are less effective with dipped headlights, especially in wet conditions. Drivers tend to engage main beam, dazzling oncoming drivers and rendering the road ahead 'pitch dark'. On the other hand, self-illuminated *cat's eyes* raise the visibility of hazardous road layouts, junctions and curves beyond the beams of vehicle headlights.

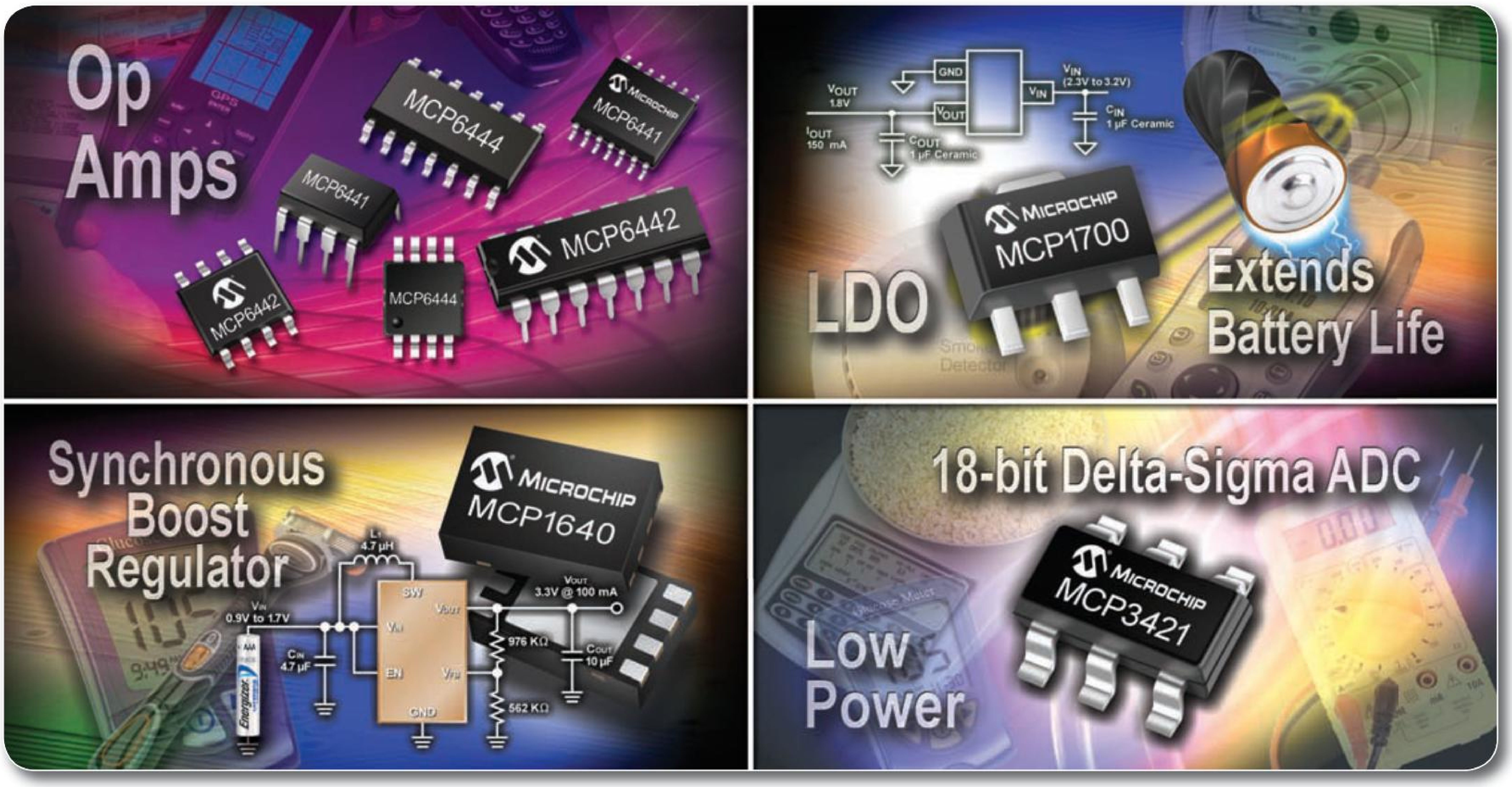
These devices are interesting technically as well. The 105mm diameter modules are self-activating and self-illuminating, incorporating solar-powered integral rechargeable batteries that provide up to 240 working hours with no solar input. Their toughened glass casing makes them capable of withstanding loads of 20 tonnes and are protected against snow ploughs. Although their working life is not stated, their cost is stated to be £4 a year.

The ultra-bright LEDs used are visible over a kilometre and provide high brightness by being driven at high currents. Normally, this operation would flatten their batteries very rapidly, so the current is delivered as a very short pulse followed by a longer rest period for the LEDs to cool down.

The repetition rate is around 250Hz, which the eye integrates so that the light point appears to be continuous. Although frequencies above 60Hz or so are considered flicker-free, a few drivers unfortunately find the flashing light of these *cat's eyes* annoying and extremely distracting.

Does Your Design Require Low Power Analog?

Microchip has the answer ...


Op Amps
MCP6444
MCP6441
MCP6441
MCP6442
MCP6444
MCP6442
LDO
MCP1700
Extends Battery Life
VOUT 1.8V
IOUT 150 mA
COUT 1 µF Ceramic
GND
VIN (2.3V to 3.2V)
CIN 1 µF Ceramic
Synchronous Boost Regulator
MCP1640
L 4.7 µH
VIN 0.9V to 1.7V
CIN 4.7 µF
VOUT 3.3V @ 100 mA
976 KΩ
562 KΩ
COUT 10 µF
SW
EN
GND
18-bit Delta-Sigma ADC
MCP3421
Low Power

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- Up to 350 mA out

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- 300 mV dropout voltage
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Putting it together . . .

DIGITAL LIGHTING CONTROLLER

Part 2 – by Nicholas Vinen and Jim Rowe

Everyone who has seen this has been pretty impressed... and no wonder! While we originally intended it to make your Christmas lights display the best in your suburb, with up to 32 channels and total power limited only by your power outlets, it's actually capable of controlling just about any lighting sequencing task you want to throw at it.

WE INTRODUCED this new *Digital Lighting Sequencer* last month and already it's created quite a stir. So how many budding Chevy Chase wannabes are there out there, anyway?

This month, we'll go through the relatively simple construction of both master and slave units, testing them and then how to use them. We'll start with the smaller of the two 'boxes', the Master Unit, which has all the 'smarts'.

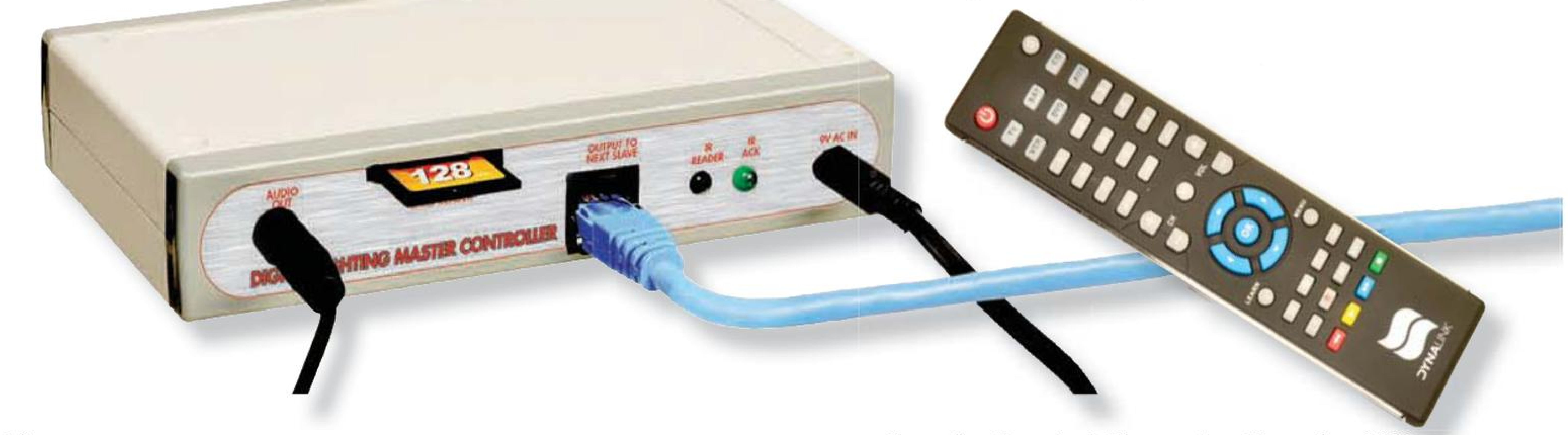
Master board construction

Before assembly, check the copper side of the PC board for defects and that the holes are drilled correctly. Test the connectors for fit. If your board is not provided with the corners cut out to suit the case, you will need to file it to shape.

First, install the SD/MMC card socket, which goes on the copper side. Remove the dummy plastic 'memory' card, then place the socket over the pads. Check that they all line up, then apply some solder to the two larger mounting pads. Ensure it is aligned and that it is sitting flat on the board – if required, re-melt the solder joints and adjust its position.

Once it is in place, apply solder to the 13 remaining pads, ensuring that the solder flows properly on to both the pins and the pads. In the case of the

Below is the master unit with a 128MB SD card in its reader. This is connected via a suitable length of Cat5 cable...



Lights II V4.indd 18 21/09/2012 09:07:04

Altronics socket, one of the mounting pads has two pins (one is ground) so make sure that the solder covers both.

After that, install the wire links using either tinned copper wire or 0Ω resistors. Follow with the resistors as shown on the overlay, Fig.4, checking each value with a multimeter before installation. Then fit the four diodes, taking care with their polarity.

Next, install the 28-pin socket for IC1, with the notch oriented as shown on the overlay. Solder two diagonally opposite pins and then check that the socket is sitting flat on the PC board before soldering the rest. Then straighten the pins of the TL072 IC and solder it in place, oriented as shown.

Using small pliers, bend the legs of the LM3940 regulator down at right angles 6mm from the tab. Attach it to the board using a 6mm M3 machine screw, shakeproof washer and nut. Once it is firmly mounted, solder the leads and then trim them.

After that, mount the 3.5mm stereo socket. Ensure its pins are straight before inserting it and check that it sits flat before soldering them.

Fit the MKT and ceramic capacitors next. Polarity does not matter, but the values do, so check the overlay diagram as you go. Follow with the single tantalum capacitor. The positive lead is normally marked with an inked '+' on the plastic body, which lines up with the '+' on the overlay.

Now install all the electrolytic capacitors except the largest (2200µF). The 4.7µF non-polarised capacitor can go in either way, but the rest must have their longer leads (+) through the hole marked '+' on the overlay.

Install the 7806 regulator next, using the same procedure as for the LM3940, but before you insert the M3 machine screw, slip the small heatsink between the regulator and the PC board. Thermal grease is not required. Make sure it stays straight as you tighten the bolt, otherwise it may touch the large capacitor, which will be adjacent to it.

Unless the 2200µF capacitor lies flat it is too tall to fit in the box. Bend its leads down about 2.5mm from its base, keeping in mind its final orientation (as shown by the '+' symbol on the overlay). Push it flat against the board, solder it in, then run a thin bead of neutral-cure silicone sealant or hot-melt glue along the side closest to the board edge to hold it in place.

Now fit the crystal adjacent to IC1. Its orientation does not matter, but avoid heating its leads too much.

Next, install the DC socket, ensuring that it is flush against the PC board and is at right angles with the board edge in both planes. Follow with the RJ-45 type II socket – push its plastic posts into their holes, then carefully solder the eight pins without bridging them. If you do manage to create a solder bridge, it can be cleaned up with solderwick.

The green LED is installed at right-angles to the PC board and in line with the edge. Bend its leads 6mm from the body, using the overlay as a guide as to the final orientation – the flat side should be lined up as shown. Solder it so it sits 7mm above the board surface.

The infrared receiver (IRD1) needs its leads bent twice. With the dome of the lens at the front, bend the leads 90° backwards 1mm from the component body, then back in the opposite direction 7mm from the first bend, forming a 'Z'-shape. Push the remaining leads all the way through the PC board before soldering them so that the 7mm section rests on the top.

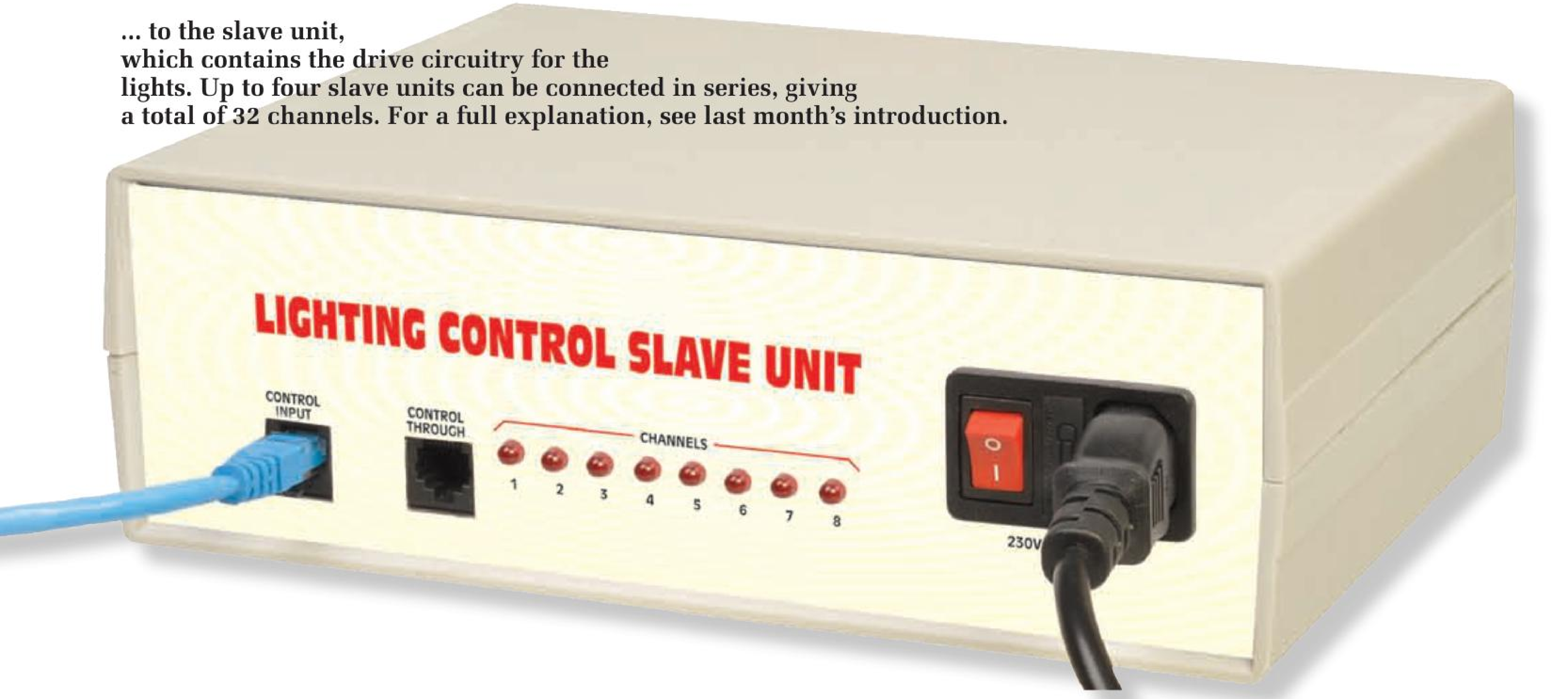
Testing the master board

Before installing IC1, check that the power supply is working. Temporarily connect a 9V AC plugpack to the power socket and measure the output (right-most pin) of both regulators relative to the tabs – they should be close to 6V and 3.3V. Assuming they are OK, remove the power supply and wait a few seconds, then install the microcontroller (IC1), being careful to line up its notch with that on the socket.

Re-apply power and the green LED should flash twice then continually ramp its brightness up and down. This tells you that the microcontroller and its zero-crossing detection circuitry are working.

If the LED does not flash, check that IC1 has been programmed correctly

... to the slave unit, which contains the drive circuitry for the lights. Up to four slave units can be connected in series, giving a total of 32 channels. For a full explanation, see last month's introduction.



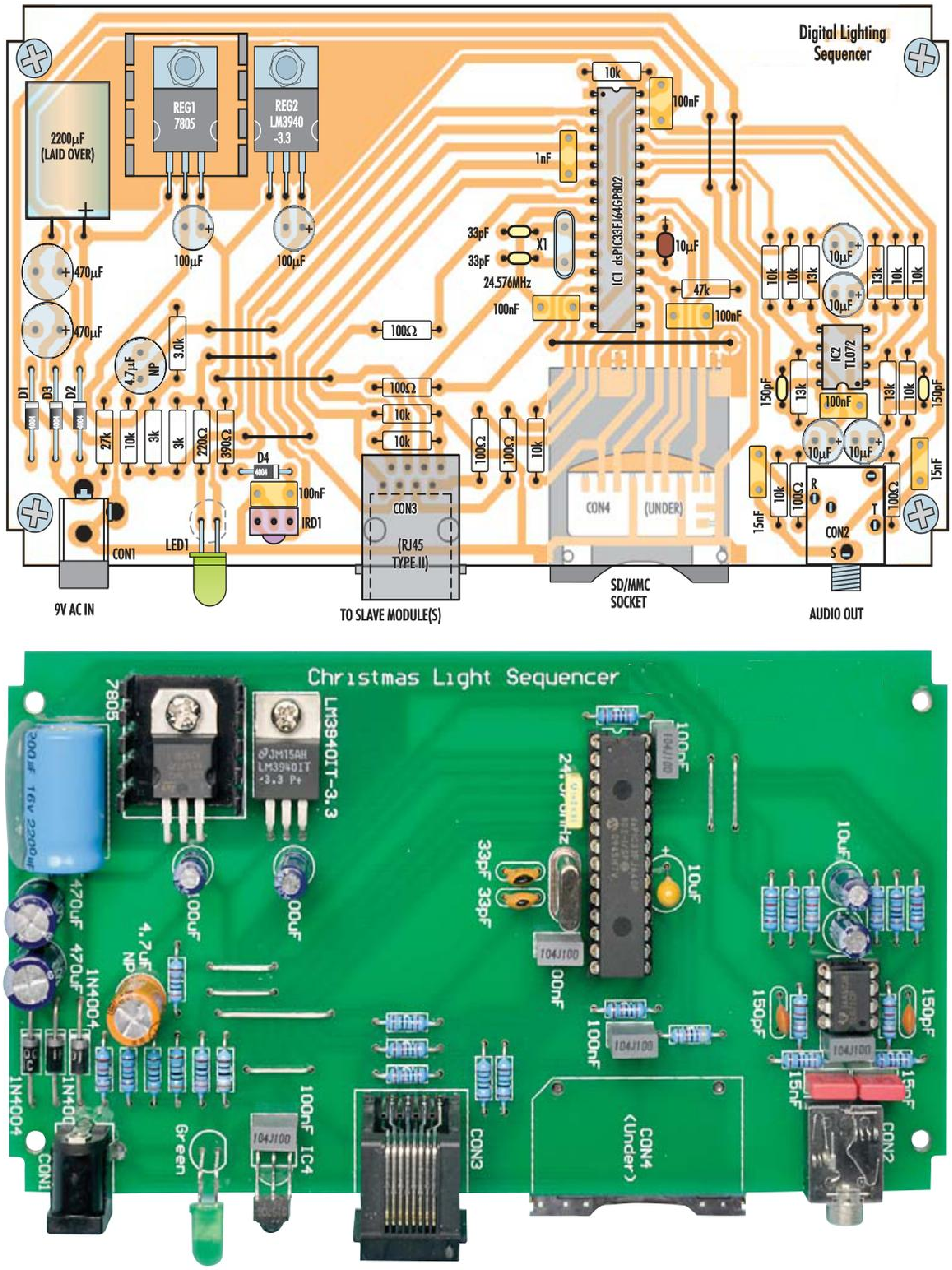

Digital Lighting Sequencer
2200µF (LAID OVER)
REG1 7805
REG2 LM3940 -3.3
100µF
100µF
470µF
470µF
4.7µF NP
3.0k
D1
D3
D2
27k
10k
3k
3k
220Ω
390Ω
D4
100nF
IRD1
LED1
CON1
9V AC IN
100Ω
100Ω
10k
10k
CON3
(RJ45 TYPE II)
TO SLAVE MODULE(S)
10k
1nF
33pF
33pF
X1
24.576MHz
100nF
IC1 dsPIC33FJ64GP802
100nF
10µF
47k
100nF
100Ω
100Ω
10k
CON4 (UNDER)
SD/MMC SOCKET
10k
10k
13k
10µF
10µF
13k
10k
10k
IC2 TL072
150pF
13k
100nF
13k
10k
150pF
10µF
10µF
15nF
10k
100Ω
R
T
S
CON2
100Ω
15nF
AUDIO OUT
Christmas Light Sequencer
7805
LM3940IT-3.3
Green
IC4
CON3
CON4 (Under)
CON2
CON1
1N4004

Fig.4: here's the component overlay for the master unit, with a matching photo underneath. Two points to note: (a) the SD card socket is mounted on the underside of the PC board, and (b) the 2200µF capacitor is mounted lying down on the PC board, with some hot melt glue or silicone sealant to hold it in place (after soldering!). We strongly suggest you use a socket for the microcontroller at least – it makes testing and trouble-shooting a whole lot easier. Note that there are some minor differences between the early prototype PC board at left and the component overlay above.

and the crystal is correctly installed. If it does not pulsate, check the passive components in the zero-crossing detection circuit.

Assuming all is OK, place a WAV file (in the standard PCM format, eg, from a CD) on an otherwise blank memory card and plug it in. The green LED should go out (it may flash twice first) and after a few seconds it should turn on fully.

If so, connect the audio output socket to an amplifier (eg, using a 3.5mm to RCA cable) with the volume turned down then slowly turn the volume up. If you hear the audio being played then the card, socket and audio output are all operating correctly.

If the LED is on, but there is no sound, check the audio output circuitry. If the LED does not turn on as described then there may be a problem with the soldering on the card socket. If the LED flashes repetitively in a pattern, this indicates that the software has encountered an error – see the table of error codes towards the end of the article.

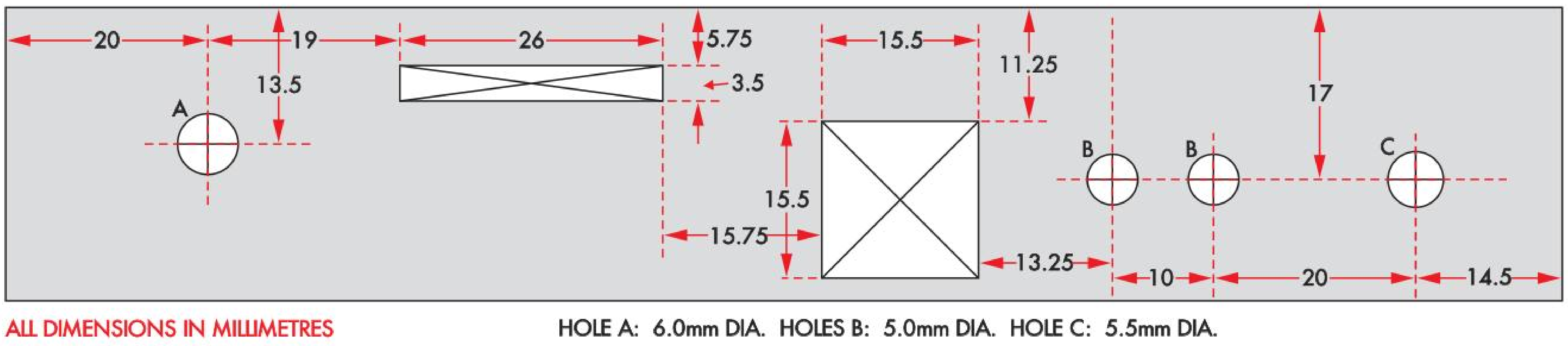
Completing the master module

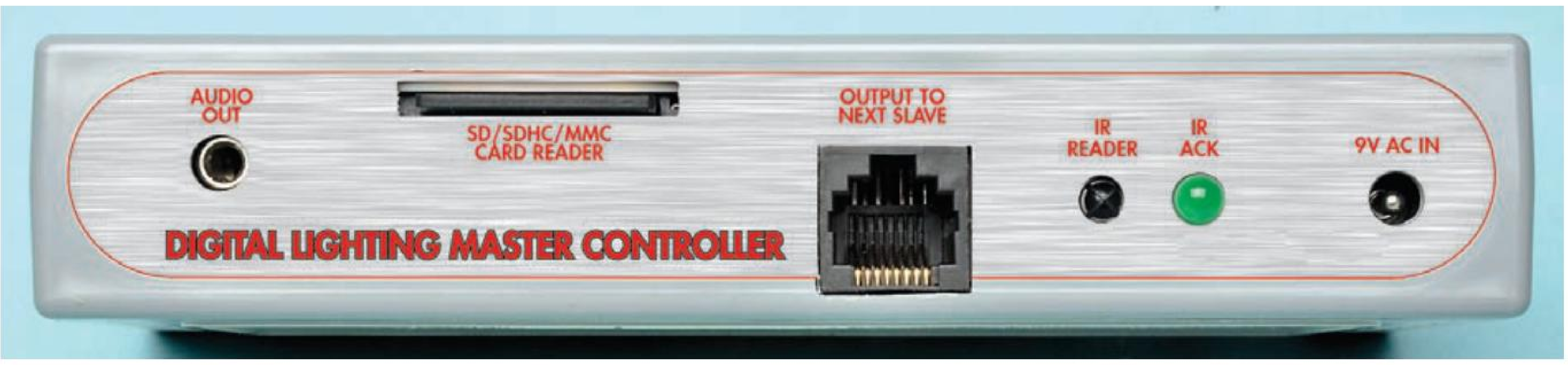
Snap the front panel off the box and cut and drill it as shown in Fig.5. A photocopy or print-out of this template can be temporarily glued on to the panel as a drilling aid.

For the round holes, drill a small pilot hole in the centre and then expand it using a series of wider drill bits, then deburr it using a larger drill bit. This ensures that the holes remain round and clean.

For the larger rectangular hole, mark the outline using a sharp knife and

Fig.5: same-size diagram showing the holes and cut-outs for the master unit. The photo below shows the same thing, this time assembled.


20
19
13.5
A
26
5.75
3.5
15.5
11.25
15.5
15.75
13.25
B
B
17
C
10
20
14.5
ALL DIMENSIONS IN MILLIMETRES
HOLE A: 6.0mm DIA. HOLES B: 5.0mm DIA. HOLE C: 5.5mm DIA.



then drill a series of closely spaced 3mm holes around the inside of the outline, then cut the remaining plastic to knock out the centre section.

Use a needle file to clean up the edges and slowly expand the opening until the connector fits neatly.

The card slot can be made using a similar technique, but the holes must be small (eg, 1.5mm to 2mm) to avoid going outside the outline. Once the slot has been filed to a rectangular shape, you may need to slightly elongate it in one direction or the other after the case is assembled to suit the alignment of the card socket.

Now mount the PC board in the case. It is attached to the lid's integral plastic stand-offs with nylon washers between them, so that the memory card can clear the lip on the lid. Place the nylon washers atop the stand-offs, then lower the PC board on top without knocking them off. Attach the board using the specified self-tapping screws.

If you can't get the board on with the washers staying in place, you can glue them to the underside of the board with a dab of hot-melt glue or other adhesive. They must be slightly offset from the centre of the holes so that they do not extend out past the board's corner cut-outs.

With the board installed, one further cutout must be made to the base lip. The specified RJ45 socket is quite tall and requires a notch, as shown in the close-up photo. Gently trim away the plastic using side-cutters and clean it up using a file. Care must be taken to avoid cracking the case or scratching the panel – the lip itself is hidden by the front panel when it is installed.

At this point, with the lid in place, the front and rear panels can be snapped on and the master module is complete. Note that when attaching the front panel you will need to lever it in place – clip on the edge with the RJ45 cutout first.

In doing so, be careful that the LED fits through the hole, otherwise its leads will be bent. Also, check that the infrared receiver sits properly behind its hole when the front panel is in place.

Once you have confirmed that all the cutouts are correct and the front panel fits properly you can stick the label in place. If it is not adhesive (ie, if you have printed and laminated it) it can be attached with a thin smear of silicone sealant.

Slave board construction

Again, check the copper side of the Slave board (Fig.6), then install the wire links. There are ten in the low voltage (bottom) section; these can be made from tinned copper wire or 0Ω resistors.

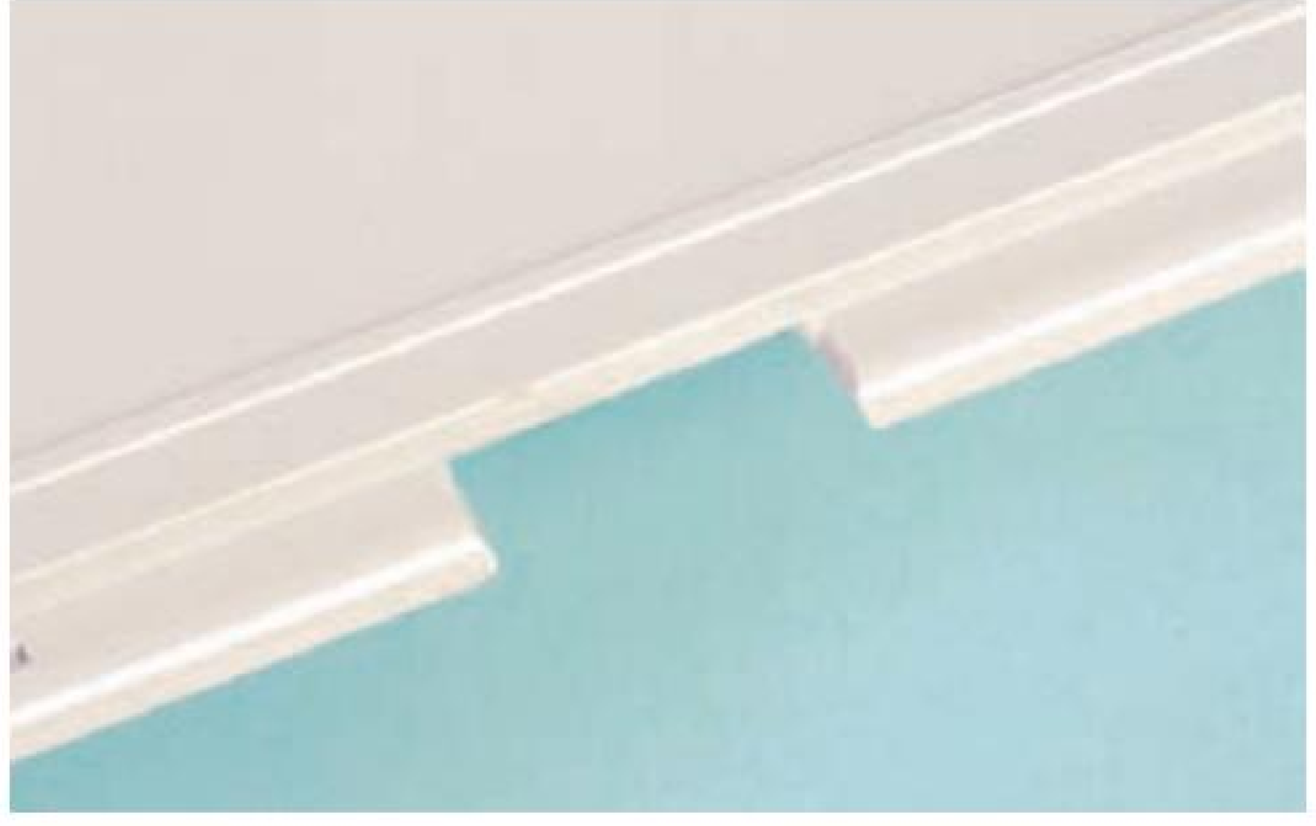
The eight links near the triacs are at mains potential, so they **must** be insulated. Cut eight 11mm lengths of 2.5mm or 3mm fibreglass sleeving and slip each over a 20mm length of tinned copper wire. Bend the ends of the wire to form 11.5mm wire jumpers and then solder them in place. When that is finished, install all the resistors. Use a multimeter before installation to be sure that they are the correct value.

Next, fit the three ICs and eight optocouplers. The ICs all have different pin counts, so it is hard to mix them up, but be careful with their orientation (see the overlay diagram). Straighten the leads and press each IC down as far as it will go before soldering it. The orientation of the optocouplers is critical, so be sure to install them with the notch towards the left side of the board, as shown in Fig.6.

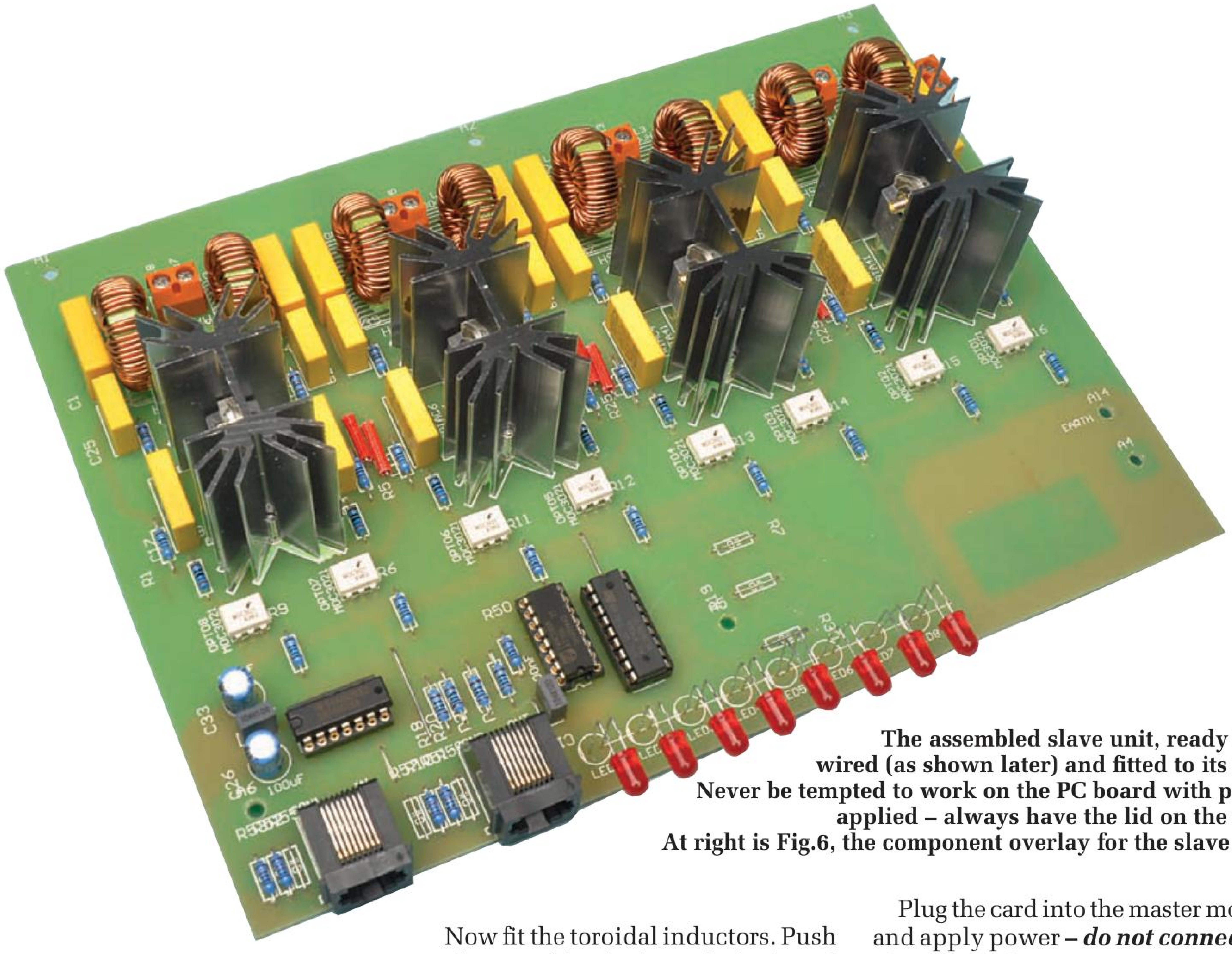
Now solder the two low-voltage MKT capacitors (at the bottom left) and the two electrolytic capacitors. The longer lead of each electro goes into one of the two holes near the '+' symbol.

After that, you can install the terminal blocks, with the openings facing towards the nearest edge of the board. Follow with the X2 capacitors, then the two RJ45 connectors. They are installed in the same manner as the master board. Ensure they are pressed down fully before soldering them.

The eight red LEDs are next, but first their leads must be bent at right



This notch needs to be cut in the case to accommodate the RJ-45 socket. Cut it as neatly as you can, but don't worry too much if your skills aren't up to scratch: it's hidden by the front panel.



The assembled slave unit, ready to be wired (as shown later) and fitted to its case. Never be tempted to work on the PC board with power applied – always have the lid on the case. At right is Fig.6, the component overlay for the slave unit.

angles 7mm from the lens. The anode (the longer lead) must go towards the right edge of the board, so bend them in the correct direction to achieve this. The horizontal portion of the leads go 16mm above the board surface. A 16mm-wide strip of cardboard can be cut to assist in positioning them.

Fit the triacs to the heatsinks in pairs – one on either side. Insert a 10mm × M3 screw through one tab, then the heatsink, then the other tab and secure with a shakeproof washer and M3 nut. Do them up tightly. As before, thermal grease is not necessary, but may be used if desired. Note that the tabs on these devices are insulated – **do NOT substitute other triacs**!

Once each triac/heatsink assembly is complete, push the leads through the holes in the PC board until the heatsinks are right against the board, then flip it over and solder the two thick posts to hold the assembly in place.

The heatsinks are quite large, so you will need to use a large tip and/or high temperature for this job. When the heatsinks are in place you can then solder and trim the Triac leads.

Now fit the toroidal inductors. Push each pair of leads through the board as far as they will go then solder and trim them.

Finally, install the Earth lug. If your spade terminal is double-ended, cut one end off first with a pair of sturdy side-cutters. Place a shakeproof washer over an M3 × 10mm machine screw and insert it through the earth mounting hole from the copper side. Place the lug over the shaft, then an M3 nut. Tighten it, with the lug oriented so that the cable won't interfere with any components. Add a second nut on top (to act as a locknut) and do it up firmly.

Testing the slave module

Test the low voltage section of the slave module before installing it in the case. Download the test data from the *EPE* website (1611010T.zip) and extract it into the root directory of a blank memory card.

With the master module power disconnected, connect the slave board to it using a short Cat5 cable. Make sure the slave board is resting on a non-conductive surface and check that you have plugged the cable into the correct (control input) connector.

Plug the card into the master module and apply power ***– do not connect the slave module to mains!***

After a brief delay, you should see the LEDs on the slave module light up in turn for two seconds each. This repeats, then after a ten-second delay, it goes into a loop where each LED fades in and out in turn.

If some of the LEDs do not light, check the corresponding LED, optocoupler and current-limiting resistor for errors. If none of the LEDs light then there is a problem around one of the digital logic ICs or one of the RJ45 connectors.

Slave module assembly

Now prepare the front panel, using Fig.9 as a guide. As with the master module, the round holes can be drilled while the others can be made by drilling a series of holes within the outline, knocking the centre out and filing them to shape.

Be careful to make the IEC connector cutout accurately, as a tight fit will ensure that it can't come loose.

After that, attach the front panel label. For maximum protection from grubby fingers, we suggest it is laminated and glued on using a thin layer

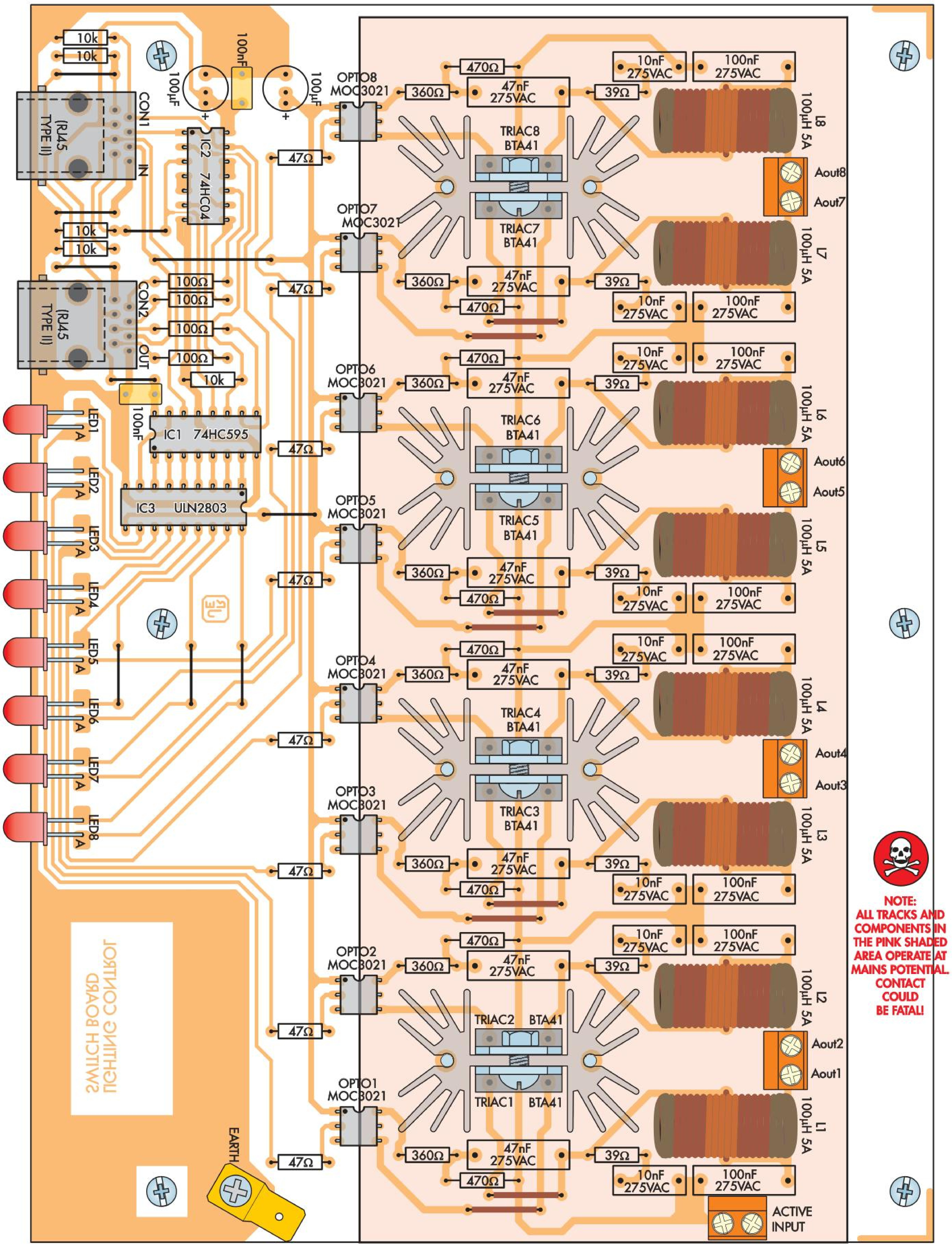

10k
10k
100nF
100µF
100µF
CON1
IN
(RJ45 TYPE II)
IC2 74HC04
OPTO8 MOC3021
470Ω
360Ω
47nF 275VAC
39Ω
10nF 275VAC
100nF 275VAC
TRIAC8 BTA41
L8 100µH 5A
Aout8
Aout7
47Ω
10k
10k
OPTO7 MOC3021
TRIAC7 BTA41
L7 100µH 5A
100Ω
100Ω
100Ω
100Ω
CON2
OUT
(RJ45 TYPE II)
10k
100nF
IC1 74HC595
IC3 ULN2803
OPTO6 MOC3021
TRIAC6 BTA41
L6 100µH 5A
Aout6
Aout5
OPTO5 MOC3021
TRIAC5 BTA41
L5 100µH 5A
LED1
LED2
LED3
LED4
LED5
LED6
LED7
LED8
A
OPTO4 MOC3021
TRIAC4 BTA41
L4 100µH 5A
Aout4
Aout3
OPTO3 MOC3021
TRIAC3 BTA41
L3 100µH 5A
NOTE:
ALL TRACKS AND COMPONENTS IN THE PINK SHADED AREA OPERATE AT MAINS POTENTIAL.
CONTACT COULD BE FATAL!
LIGHTING CONTROL
SWITCH BOARD
OPTO2 MOC3021
TRIAC2 BTA41
L2 100µH 5A
Aout2
Aout1
OPTO1 MOC3021
TRIAC1 BTA41
L1 100µH 5A
EARTH
ACTIVE INPUT

Fig.6. Component layout for the slave module board

of silicone sealant – or it can be printed on adhesive-backed paper.

With the label in place, the IEC connector can be snapped in. Make sure it is the correct type, designed for mounting on a 1.5mm panel, or else it will not be secure. If it is all sloppy in the cutout, we suggest a couple of dobs of suitable glue around the edges (inside) to keep it tight.

Push the LEDs and RJ45 connectors on the main board through the front panel and lower the whole assembly into the plastic case, with the front panel in its recess.

If your case has a vent in the bottom, orient the board so that this vent is towards the front (low voltage) end. Screw the board on to

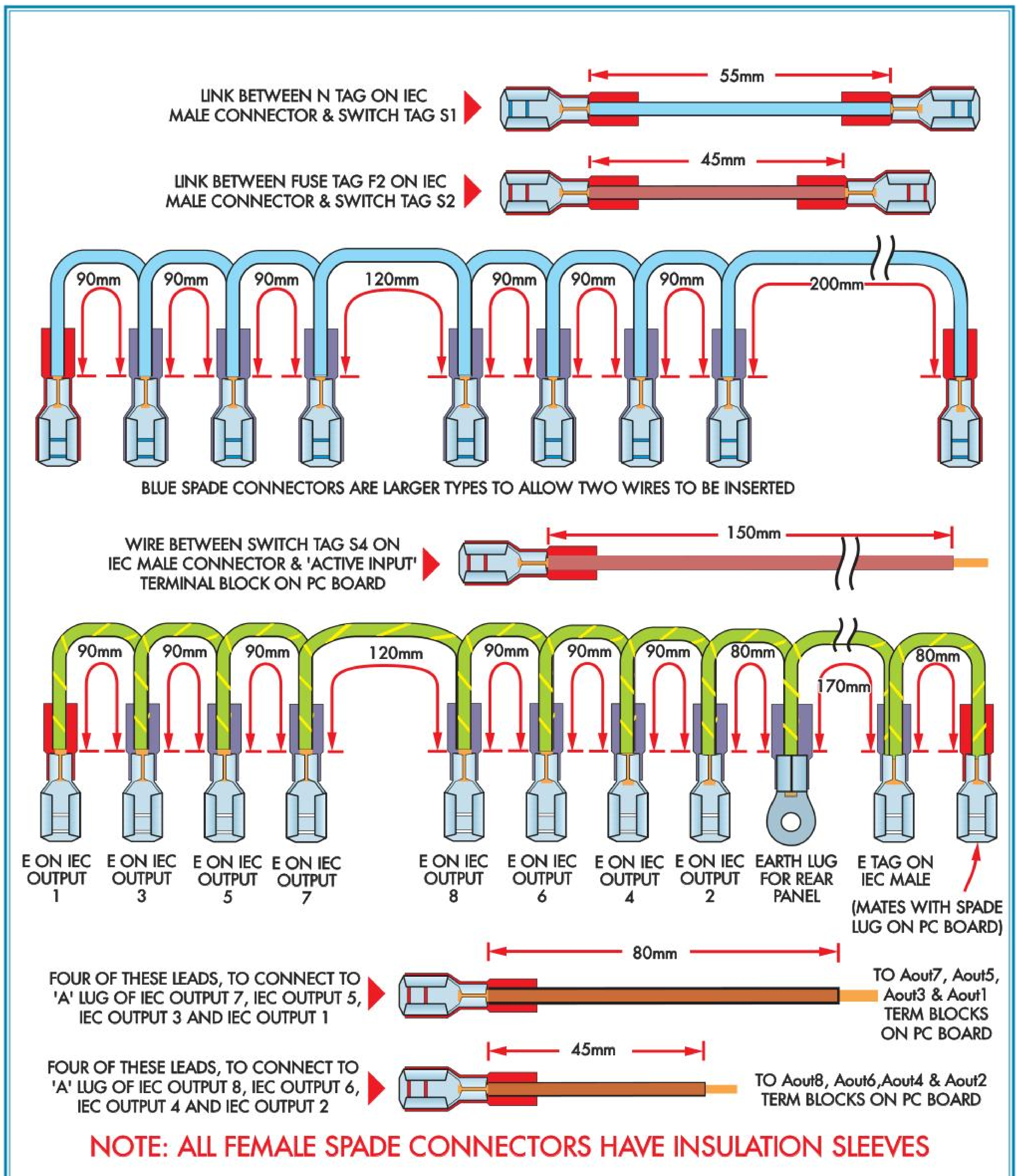

55mm
LINK BETWEEN N TAG ON IEC MALE CONNECTOR & SWITCH TAG S1
45mm
LINK BETWEEN FUSE TAG F2 ON IEC MALE CONNECTOR & SWITCH TAG S2
90mm
90mm
90mm
120mm
90mm
90mm
90mm
200mm
BLUE SPADE CONNECTORS ARE LARGER TYPES TO ALLOW TWO WIRES TO BE INSERTED
150mm
WIRE BETWEEN SWITCH TAG S4 ON IEC MALE CONNECTOR & 'ACTIVE INPUT' TERMINAL BLOCK ON PC BOARD
90mm
90mm
90mm
120mm
90mm
90mm
90mm
80mm
170mm
80mm
E ON IEC OUTPUT 1
E ON IEC OUTPUT 3
E ON IEC OUTPUT 5
E ON IEC OUTPUT 7
E ON IEC OUTPUT 8
E ON IEC OUTPUT 6
E ON IEC OUTPUT 4
E ON IEC OUTPUT 2
EARTH LUG FOR REAR PANEL
E TAG ON IEC MALE
(MATES WITH SPADE LUG ON PC BOARD)
80mm
FOUR OF THESE LEADS, TO CONNECT TO 'A' LUG OF IEC OUTPUT 7, IEC OUTPUT 5, IEC OUTPUT 3 AND IEC OUTPUT 1
TO Aout7, Aout5, Aout3 & Aout1 TERM BLOCKS ON PC BOARD
45mm
FOUR OF THESE LEADS, TO CONNECT TO 'A' LUG OF IEC OUTPUT 8, IEC OUTPUT 6, IEC OUTPUT 4 AND IEC OUTPUT 2
TO Aout8, Aout6,Aout4 & Aout2 TERM BLOCKS ON PC BOARD
NOTE: ALL FEMALE SPADE CONNECTORS HAVE INSULATION SLEEVES

Fig.7: you'll need to make up a set of cables with spade connectors, as shown, to complete wiring the slave unit. Both the cables and spade connector sleeves should be the same colours as shown here to ensure there are no mixups between active (live), neutral and earth wires. (The blue sleeves allow for two wires).

the plastic risers using self-tapping screws.

Now prepare the rear panel. If you are building the module from a kit, the rear panel may be supplied pre-cut. Otherwise, cut a piece of 2mm thick aluminium (or 1mm steel) to shape as shown in Fig.9. The eight cutouts are best made using a nibbling tool.

To accurately nibble the cutouts, print or photocopy the template, glue it to the panel (spray glue is ideal) and nibble out the holes to the lines on the template. Use a file to clean up the holes and remove any burrs. At the same time, drill the seventeen holes and de-burr them with a larger drill.

Connectors

Once everything fits, peel off the temporary label and clean with solvent (meths) if necessary. Then install the eight connectors using 10mm M3 machine screws, shakeproof washers and nuts.

You may have noticed that we used snap-in female IEC connectors in our prototype, but specified screw-mount types in the part list.

This is because the snap-in connectors can easily fall out when used on a panel this thick (necessary due to the amount of metal removed for the connectors). Screw-mounted IEC connectors are much safer in this application.

Now cut 250V AC-rated wire to length and attach crimp connectors, as shown in Fig.7. To ensure the wires cannot come loose, you must use a ratchet-type crimping tool.

Be sure to use the connectors with the correct colour, as shown, since they are designed for different thicknesses of wire (the blue connectors are designed for thicker wire so are suitable for joining two smaller diameter wires).

Complete the slave module wiring using Fig.8 as a guide.

You may need to bend some of the spade terminals on the IEC connectors upwards to get the wires past the inductors. If so, bend them carefully using pliers, to the minimum extent possible, so that the insulated connectors still cover the exposed metal. Be sure to plug the connectors in all the way so they can't come loose.

The rear panel earth lug is attached using a 10mm M3 screw. Pass it through from the rear then place a shakeproof washer on the shaft, then the eyelet lug, another shakeproof washer and two nuts, which are tightened very firmly. If there is any coating on the rear panel, it must be scraped away around the earth lug hole to ensure a good electrical contact.

Use cable ties to secure the wires so that they are held away from the components on the board and to prevent any wires from moving around and

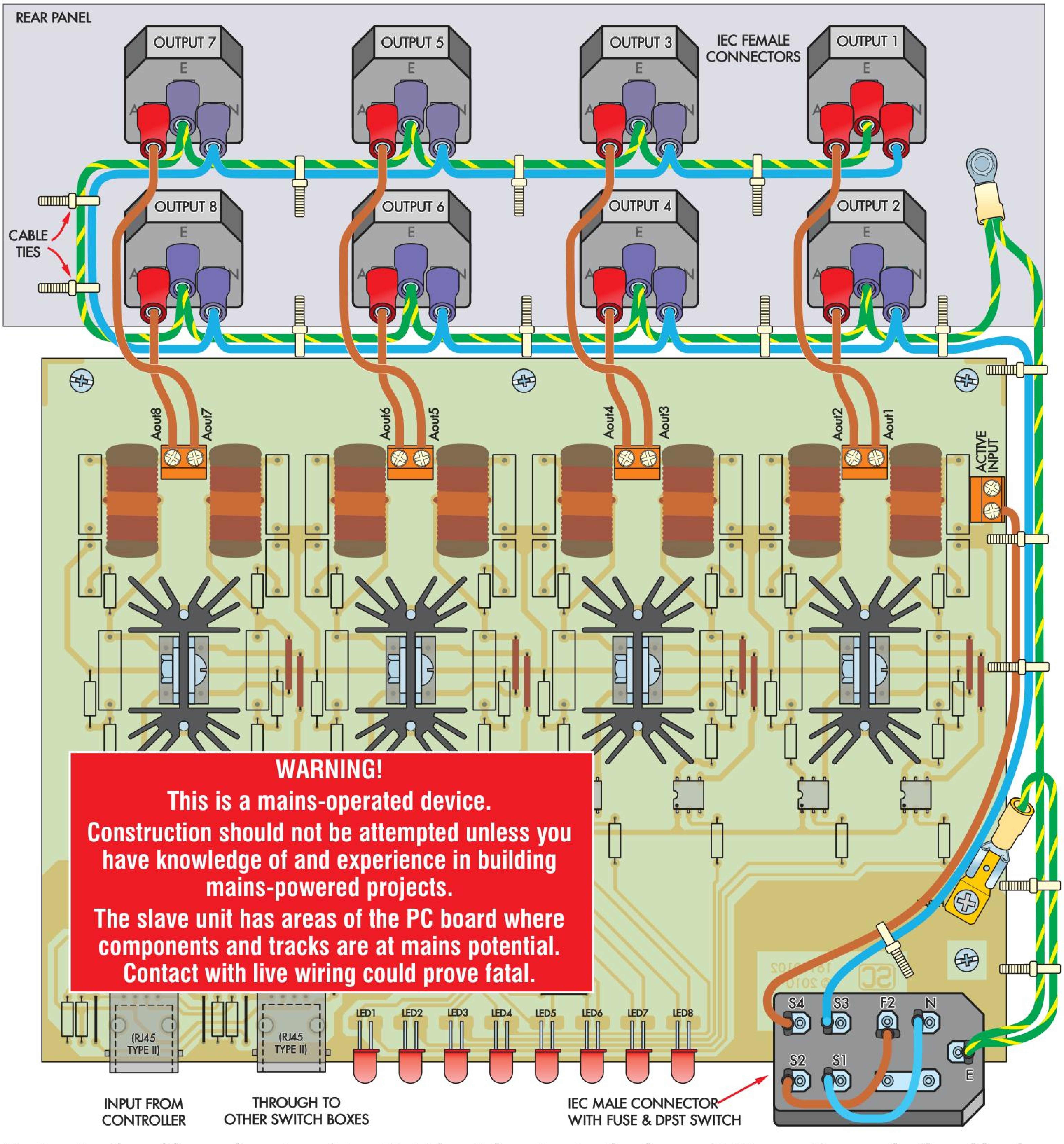
Notes

It is a good idea to use a socket for the microcontroller in case it needs to be removed for re-programming.

Regarding the RJ45 sockets specified, there are several sockets with similar pin configurations that should theoretically work, but we have not tested them.

While the ones we specified are 'Type II' (ie, the pins are at the top), 'Type I' (with the pins at the bottom) should also work as long as you use the same type on all the modules.

We have only tested the connectors specified in the parts list, so if in doubt, stick with those.


REAR PANEL
OUTPUT 7
OUTPUT 5
OUTPUT 3
IEC FEMALE CONNECTORS
OUTPUT 1
OUTPUT 8
OUTPUT 6
OUTPUT 4
OUTPUT 2
E
A
N
CABLE TIES
Aout8
Aout7
Aout6
Aout5
Aout4
Aout3
Aout2
Aout1
ACTIVE INPUT
LED1
LED2
LED3
LED4
LED5
LED6
LED7
LED8
(RJ45 TYPE II)
(RJ45 TYPE II)
S4
S3
F2
N
S2
S1
E
INPUT FROM CONTROLLER
THROUGH TO OTHER SWITCH BOXES
IEC MALE CONNECTOR WITH FUSE & DPST SWITCH

WARNING!
This is a mains-operated device.
Construction should not be attempted unless you have knowledge of and experience in building mains-powered projects.
The slave unit has areas of the PC board where components and tracks are at mains potential.
Contact with live wiring could prove fatal.

Fig.8: using the cables made up to suit (see Fig.7) here's how to wire the slave unit. It's easy if you make the cables the right lengths and terminate them with spade lugs, as shown.

working their way loose. The lid can then be installed using the supplied machine screws.

Finally, insert the two 10A fuses into the mains input connector (15A for 115V mains). One is a spare.

Final test

First, a warning. ***Never plug the slave module into the mains without the lid in place.***

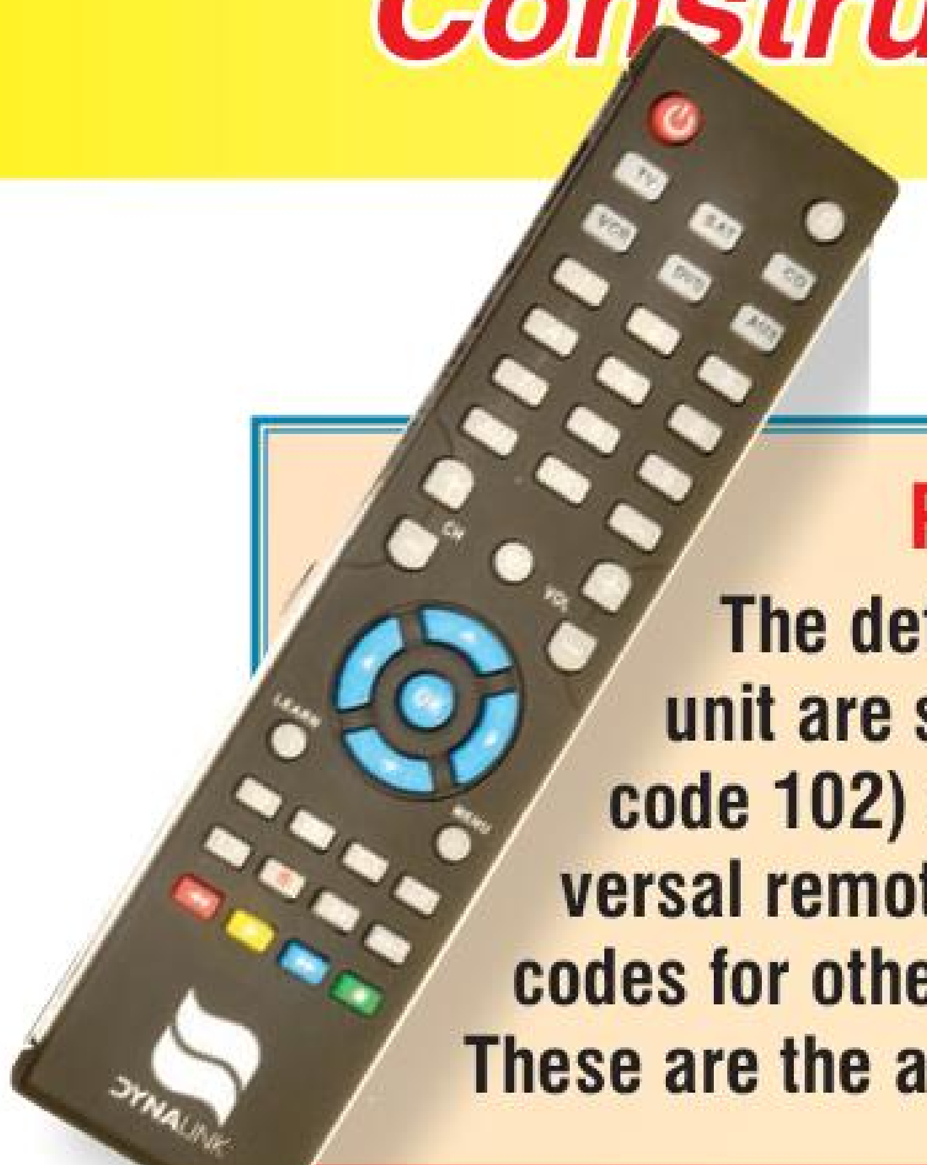
If you ever need to remove the lid, unplug the module first, and before re-installing it, check that the mains wiring is secure and safe.

The whole project can now be tested. Use the same files on the memory card and the same set-up as previously, but this time connect some lights.

For testing (which involves phase control), use 230V incandescent lamps only, not LEDs with a switch-mode supply. While it is unlikely that a switch-mode supply would be damaged by a brief period of phase control, it certainly won't like it!

Later, in use, LEDs with switch-mode supplies may be switched on and off using this sequencer, but should never be dimmed or faded.

Join the Master and Slave modules together, plug the slave module into mains and switch it on. Then



Remote control

The default remote control codes for the master unit are set up initially for a Jaycar AR1726 (TV code 102) or Altronics A1012 (TV code 156) universal remote. We explain later how to customise the codes for other remotes.

These are the available functions:

Button	Command	Description
Play	play	Starts or resumes playback
Stop	stop	Stops playback. Pressing it twice will go back to the first file
Pause	pause	Pauses or resumes playback
Channel +	next	Goes to the next sequence/WAV file
Channel –	prev	Goes to the previous sequence/WAV file
Volume +	volup	Increase audio volume
Volume –	voldn	Decrease audio volume
Fast forward	forward	Skip ahead 10 seconds
Rewind	back	Skip backwards 10 seconds
1-9, 0	1, 2,…10	Jumps to the first, second, third etc sequence/WAV file on the card and starts it immediately. Playback will stop when it finishes.
Power	reset	Stops playback and goes back to the first file
Record	order	Changes the playback order in this sequence: sorted, shuffle, directory, sorted. . . See 'Configuration' for more details.

Error flash codes

If something goes wrong, the master module flashes its LED in a pattern. This pattern involves a specific number of slow and fast flashes which repeat after a delay. To determine what has gone wrong, count the flashes and then look them up in the following tables:

No of Slow flashes	When error occurred
1	While re-programming the main program
2	While re-programming the bootloader
3	During operation (in the main program)

No of Fast flashes	Meaning
1	Failed to initialise memory card after 3 attempts
2	FAT file system not recognised
3	Could not find root directory
4	Re-programming completed, but verify failed
5	HEX file read error
6	HEX file format invalid
7	Failed to detect valid mains frequency
8	Unexpected error while re-flashing bootloader
9	Memory card indicates wrong supply voltage
10	Memory card command time out
11	Configuration file contains invalid line(s)
12	No sequences found on memory card
13	Invalid WAV file on memory card
14	Unsupported WAV file format detected
15	Memory card file read error

apply power to the master module and check that the lights operate as expected.

Using the controller

While the photo last month shows the master module sitting on top of the slave module, in practice it is a good idea to separate them by at least 50cm and if possible, run them from separate mains outlets.

The reason is that the 100Hz/120Hz triac switching generates a fairly significant amount of EMI (electromagnetic interference). The LC filter at each output reduces but does not eliminate the radiation. Most of the emissions are from the cabling between the controller and the lights.

As a result, if the master module is too close to a slave module then a buzzing sound can be coupled into the audio output. By keeping the modules physically separated and also separating the mains wiring this effect is minimised.

Creating sequences

In order to create a truly spectacular light show you need to make a sequence for each piece of music.

We have supplied a sample sequence along with a public domain Christmas song which you can download from the *EPE* website.

To create your own sequence you will need to download and install our Windows sequencing software.

The first step in creating a sequence is to open a WAV file. Select the File->New command and you will be prompted to select the WAV file. At this point, a blank sequence is created.

From top to bottom, the application window is separated into the following sections: menu, toolbar, audio display, sequence display and light status bar. The menus give you access to all functions, while the toolbar provides more convenient access to the most commonly used function.

Move the mouse over a toolbar button and leave it there to display a 'tooltip', which explains what that button does. Buttons which cannot be used are 'greyed out', and in this case the tooltip will explain why. The tooltips also indicate the shortcut key combination (if available) to activate that function.

Below the toolbar is a representation of the WAV audio data, shown as it would be on an oscilloscope. If you place the mouse cursor over that section, the scroll wheel (or menu/toolbar functions) can zoom in and out. Right-clicking or right-dragging the mouse will scroll the display, as will moving the scrollbar at the bottom of the window.

You can get a feel for how the audio display works by pressing

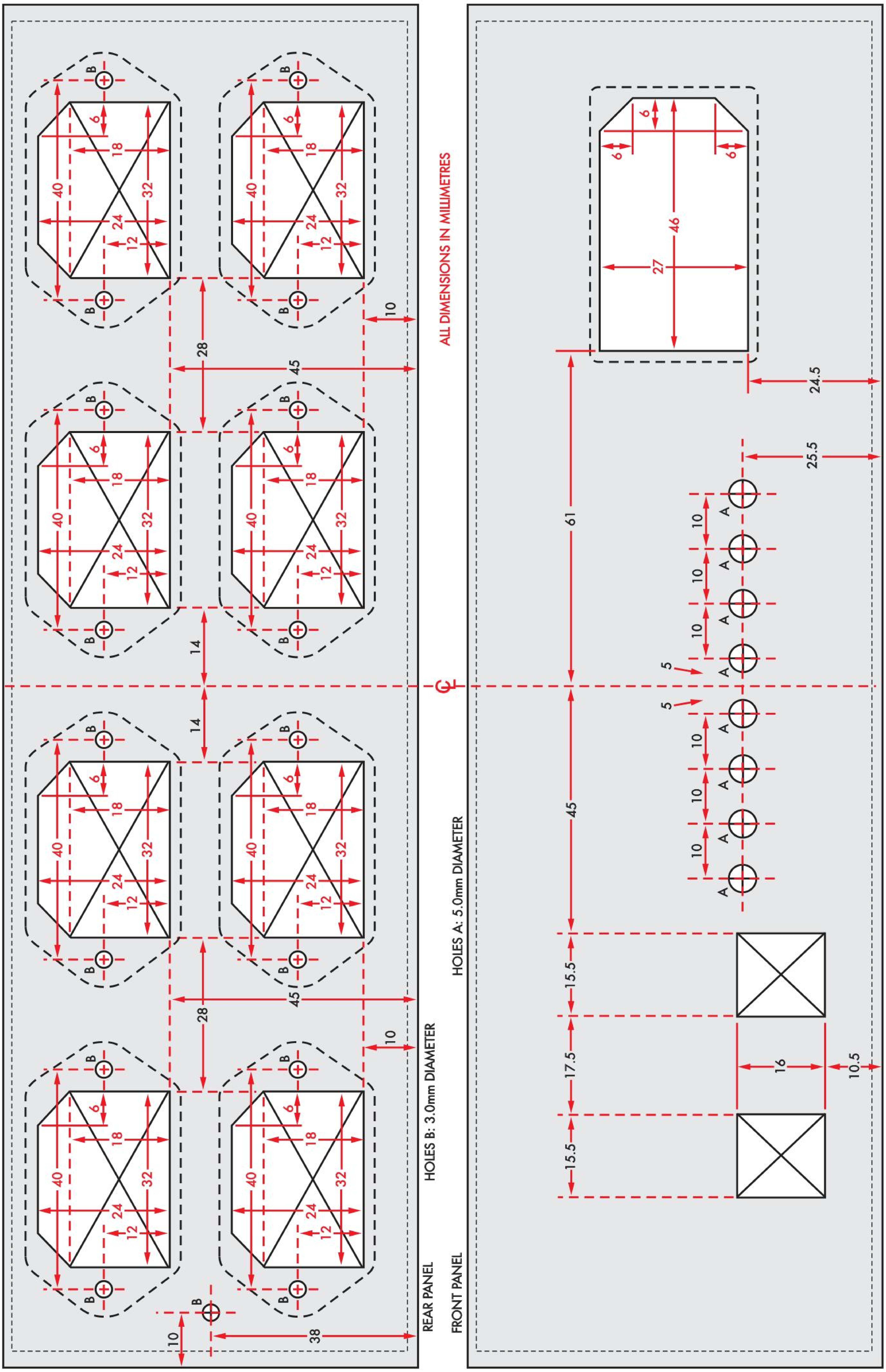

ALL DIMENSIONS IN MILLIMETRES
HOLES A: 5.0mm DIAMETER
HOLES B: 3.0mm DIAMETER
REAR PANEL
FRONT PANEL
A
B
40
6
18
32
24
12
28
45
14
10
38
61
46
27
24.5
25.5
5
15.5
17.5
16
10.5

Fig.9: same-size diagrams show the cutouts and holes required for the rear panel (left) – all IEC connectors, and the front panel (right) with cutouts for the RJ45 plugs, the IEC mains connector/fuseholder/switch and holes for eight LEDs.

Configuration

The master module's default behaviour should be adequate for most users. You just need to load your music and sequence files on to the memory card, plug it in and switch it on.

However, some users may want to alter the master unit's behaviour. To do so, place a text file in the root directory of the memory card and rename it to 'Light Controller.cfg'. In Windows, it can be edited by opening Notepad and dragging this file into the main window.

In this file, each option is written on a separate line, with the option name on the left, then an equals sign ('='), then the value for that option. The possible options are as follows, with the default shown in ***bold italics***:

start playback automatically = ***yes***, no	If yes, the first file on the card is played immediately. Otherwise playback must be started via the remote control.
start file = "filename"	If set, the file of the name specified will be the first played. Otherwise the first file found is used.
default file order = ***sorted***, shuffle, directory	If set to sorted, files will be played in alphabetical order. If set to shuffle, files will be played in a randomised order. Otherwise, files will be played in the order that they are stored.
default volume = ***100%***	Allows you to reduce the initial volume. It is better to use an external volume control if possible.
default repeat all = ***yes***, no	If set to yes, when the last file finishes playback will start again at the first. Otherwise playback will stop.
filament preheat amount = ***20***	The fraction of full power to use for the filament preheat. It is a number between 0 and 255, where 255 means full power. The default should suit most incandescent lamps.
filament preheat <slave> = ***yes***, no	Controls filament preheating on a per-slave basis. <slave> is replaced with the slave number between 1 and 4. Slave 1 is the slave closest to the master module.
filament preheat <slave>:<channel> = ***yes***, no	Controls filament preheating on a per-light basis. <channel> is replaced with the channel number between 1 and 8.
triac turnoff <slave> = ***immediate***, delayed	If set to delayed, the trigger pulses for the specified slave will be held until the end of each mains half cycle. Read the section on delayed turnoff before using this option.
triac turnoff <slave>:<channel> = ***immediate***, delayed	As above, but allows control on a per-channel basis.
remote code <command> = ***RC5***(0x????) or NEC(0x????)	Allows the unit to be configured for different remote controls. See 'remote control configuration' for more information.
infrared logging = ***off***, on	If set to on, the unit will log all infrared activity to a file. This assists with reconfiguring the codes.

Here is an example configuration file:

```
default file order = shuffle
filament preheat 1:7 = off
filament preheat 1:8 = off
triac turnoff 1:3 = delayed
triac turnoff 1:4 = delayed
```

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the 'play file' button with speakers or headphones connected to the computer.

Below the audio data display are the sequencer light states, which scroll together with it.

The brightness of each horizontal strip represents the brightness of the light as time passes. By clicking on a portion of the audio data, you can see the state of the lights at that point in the sequence on the light status bar, at the bottom of the window.

This bar is also active during playback to provide a sequence preview.

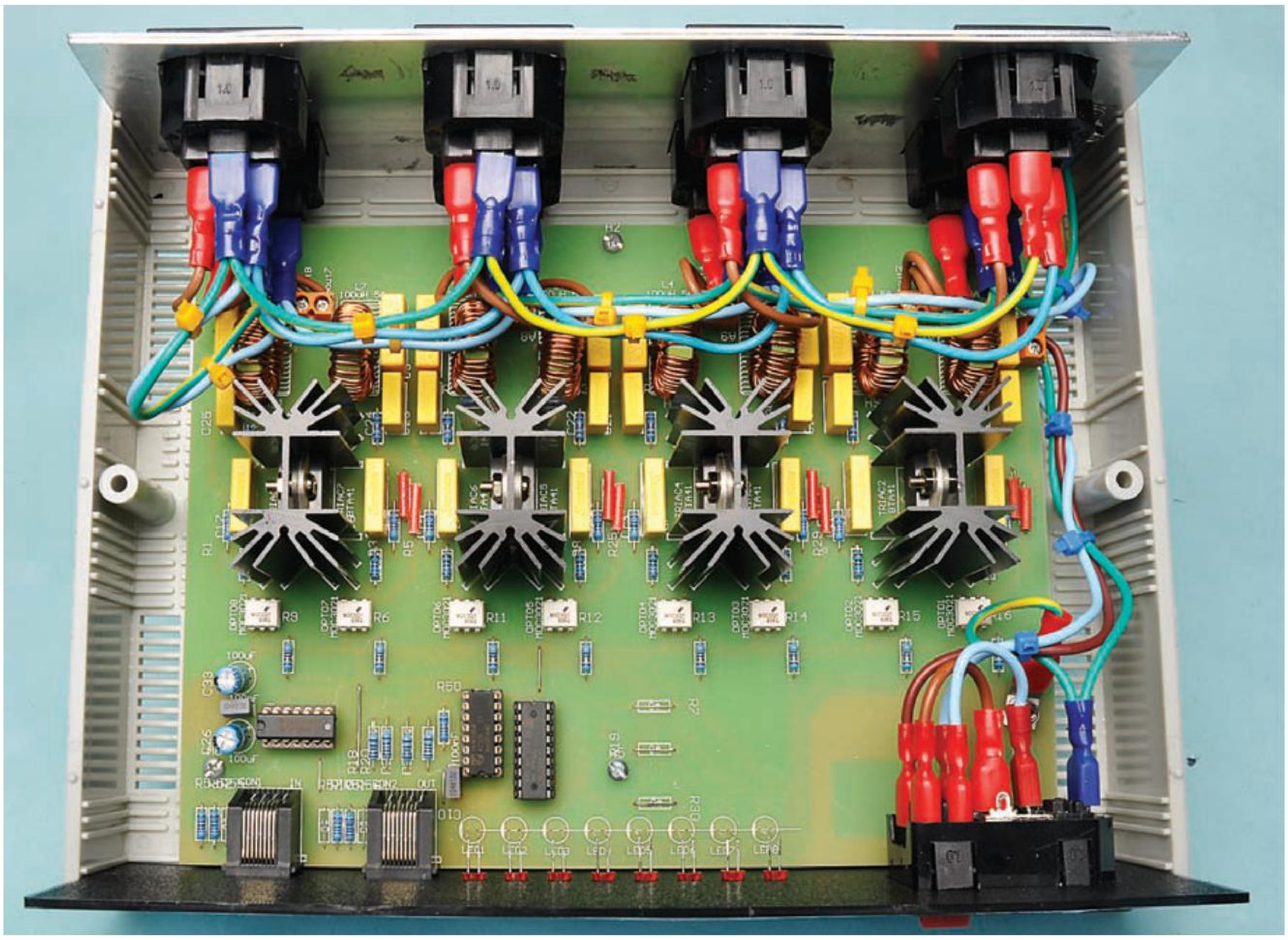
Manipulating the sequence

Click and drag the mouse within the sequence area to select a portion, which will turn blue. You can move the start and end of the selection by dragging them. It is also possible to select from the audio display.

Which lights are selected can be changed by clicking on the light names at the left of the window. Control-click and shift-click allow you to select multiple lights.

Once a selection has been made, you can manipulate that portion of the sequence using the functions towards the right-hand side of the toolbar (or from the Lights menu).

These include turning the light(s) on or off for that period, setting them to an intermediate brightness, ramping the brightness up or down or performing a 'cascade' where the lights are turned on in sequence.



Inside the completed slave unit – this shows push-fit IEC connectors on the rear panel, but with 20:20 hindsight, we now recommend captive types (with screws and nuts). For safety, follow our wiring diagrams and photos exactly!

The best way to understand how these functions work is to experiment with them. After changing the sequence, you can play it (or a section of it) to get an idea of what it will look like.

The easiest way to do this is to select the section of the file you are working on and press the 'set play region' button on the toolbar. You can then use the 'Play region' function to play this section at any time as you are working on it.

If you make a change that you are not happy with, simply use the 'undo' function to revert it.

Auto-sequencing

For automated sequence creation there is the 'beat detection' function, which pulses one or more lights in time with the beat; the 'spectrum analysis' function, which behaves like a 'Musicolour'; and even an 'automatic sequencing' function, which can generate a complete sequence with just a few mouse clicks.

The GUI (graphical user interface) is designed to be easy to learn, so with a little experimentation you should be able to figure out most of its functions. We don't have enough room for a more detailed explanation this month, but we will provide more information next month.

Delayed turnoff

The delayed turnoff option should only be used in two situations – either during testing, to allow the slave indicator LEDs to vary their brightness or else for channels with lights that have insufficient current to properly latch the triacs (<25W or so). If the brightness of your lights is not being properly controlled, you may need to use this option.

In the latter case, only enable delayed turnoff for the affected channels. It is not a good idea to have more than a few such channels, as this results in higher current drain on the 6V line. This can cause excessive heat generation in the 7806 regulator and higher voltage drops across long Cat5 cables, possibly resulting in incorrect operation.

Ideally, use lights with a high enough power rating to allow the triacs to latch.

Remote control configuration

Up to three remote control codes can be assigned to each command. These can be Philips RC5 12-bit codes or NEC 16-bit codes (used by some Digitech remote controls). Either way, the code is specified as a 4-digit hexadecimal number.

Do not worry about what this means, as the infrared logging feature can tell you what codes your remote control uses. Simply enable the feature, turn the unit on and press the buttons you are interested in. All you then need to do is open the log file on your computer, copy the codes into the configuration file as appropriate, and disable the logging feature.

The format for an RC5 code is 'RC5(0×1234)' and for an NEC code it is 'NEC(0×1234)'. For example, to configure the master module so that RC5 code 0x0020 triggers the 'next' command (which is the default), add the following line to the configuration file:

```
remote code next = RC5(0x0020)
```

To add two to four possible remote codes for a given command, separate them with commas.

RFID Security System

Here's a high-security system that's very easy to build, but offers you peace-of-mind for your home, car – in fact, anything where entry needs to allow the good guys in but reject the bad guys. Team it with an electric lock and you have a keyless entry system as well!

IT'S A sad fact that in today's world the need for property security is ever present. Our homes and businesses are a target for thieves and other criminals.

We spend countless amounts of money on systems that have been designed to counter the would-be bad guys.

The complexity of these systems ranges from a simple sticker that proclaims 'Batman will jump through the window and zap any burglar stupid enough to attempt robbing the premises', all the way up to computer-controlled alarms systems that use satellites to protect our property and warn of a crime in progress.

Although the system presented here does not communicate with satellites, it will give a high level of protection and control access to any structure that it is monitoring.

RFID?

If you have a key fob for access to offices at work, a micro-chipped pet or a late-model car with an immobiliser key, then you're already using radio frequency identification (RFID) technology. Although RFID is not a new field, and it has been written about in this magazine in the past, it is now available as a project for any person who wants to protect their property from unauthorised access.

This system will give control over who has access to your home, car or any other building you care to mention. The system is installed in a position that will allow the users access to the protected building.

A tiny (keyring-sized) RFID tag is held close to the sensor. The system detects the tag and compares its 'signature' with those stored in memory (up to eight).

If, and only if, a match is found, an on-board relay is enabled for one second. This relay could be used to disarm a burglar alarm or unlock a door.

If the detected tag is not one of those stored in memory then the system can be used to trigger an alarm or to sound a warning that an unauthorised access has been attempted.

The advantage of this is that tags can be changed and the system re-programmed at will, so if a tag is stolen, or even if someone attempts entry who is no longer allowed, that tag will have no effect except to flag an unauthorised entry attempt.

Operation

RFID operates by generating a magnetic field and then looking for any modulation on that field – see Fig.1. RFID 'tags', when bought within range of the scanning coil will send out a unique series of bits.

In our system, The on-board microprocessor decodes these bits and outputs a data frame from pin 1 which is sent to RB0 (pin 6) of IC1.

The range of this system is around 4cm which, although not a lot, is ideal for the application presented here.

The full circuit diagram in Fig.2 shows that there is not much to the system at all. The RFID part consists of a pre-built module that generates the necessary RF field used to scan the tags as they are bought within range of the scanning or detection coil.

As well as 'reading' the data from the tag, the coil also provides power to the

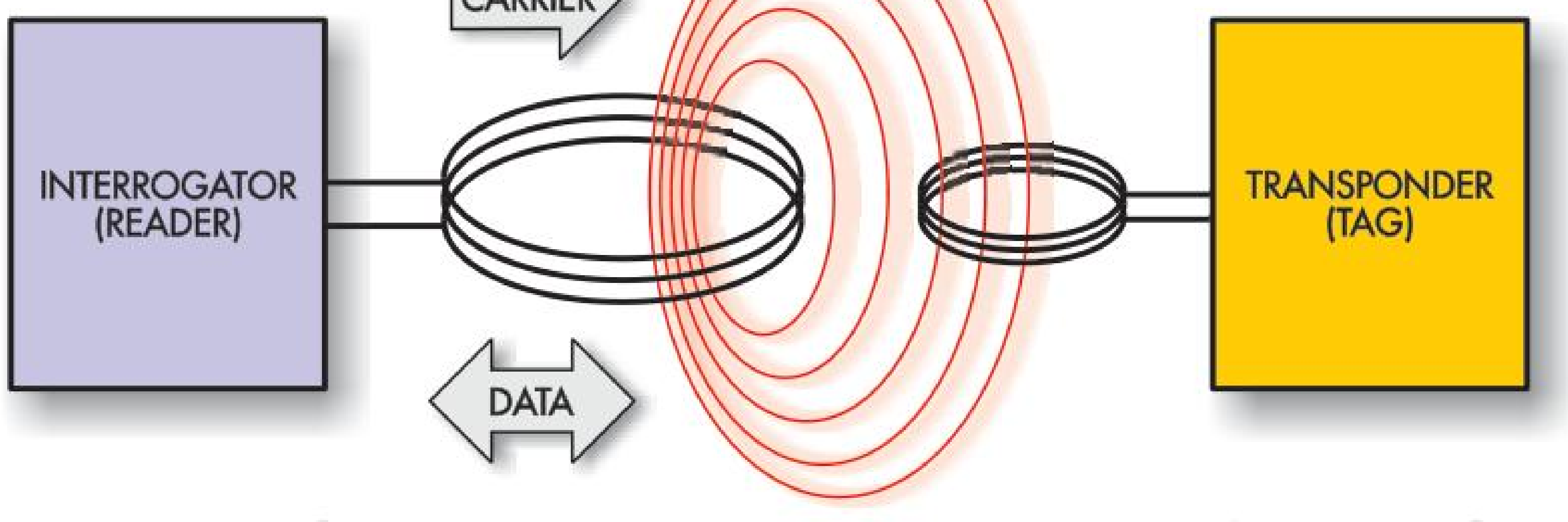
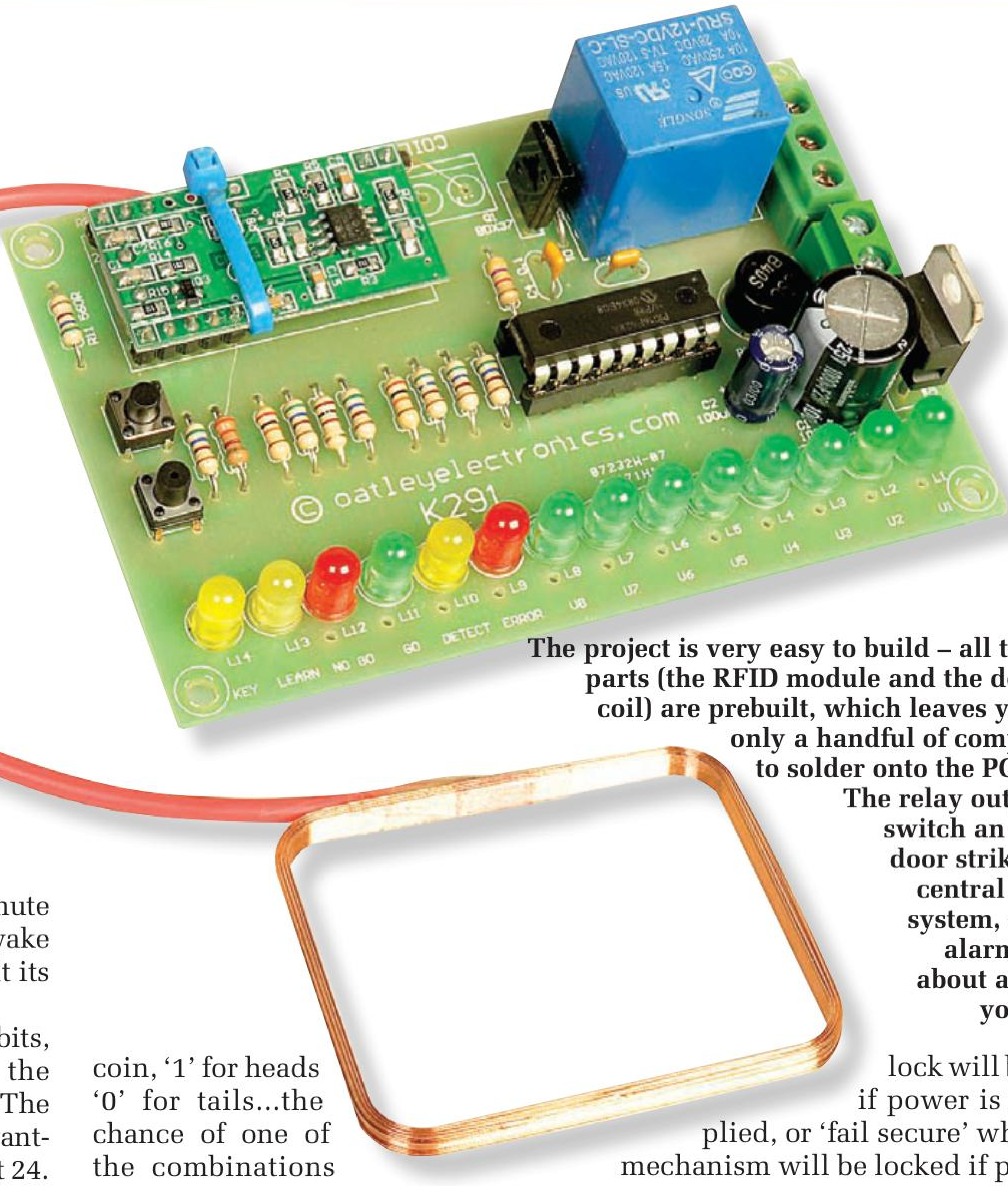


Fig.1: a basic RFID setup consists of a reader (or interrogator) and transponder. Low frequency systems rely on inductive coupling to provide transponder power.



The project is very easy to build – all the hard parts (the RFID module and the detection coil) are prebuilt, which leaves you with only a handful of components to solder onto the PC board. The relay output can switch an electric door strike, a car central locking system, another alarm or just about anything you want!

by Jeff Monegal

tag via inductive coupling. It's a minute amount of power, but enough to 'wake up' the tag and cause it to transmit its unique code back to the coil.

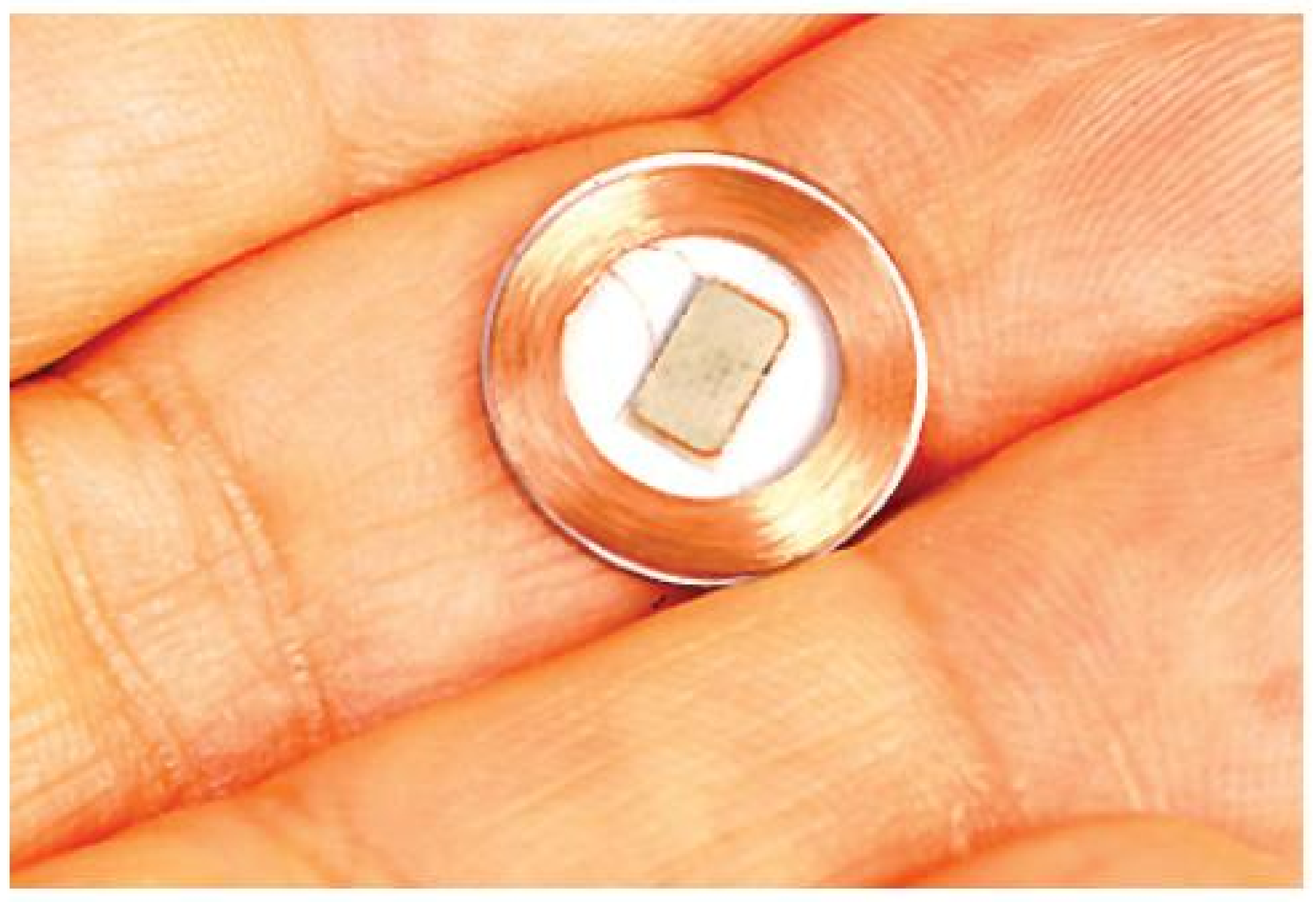
The data frame consists of 42 bits, which is detected and fed to the PIC16F628 microprocessor (IC1). The internal software strips off the unwanted bits of the frame to leave the last 24.

If you think that this cuts down on the number of different combinations, then consider this: 24 bits = 2 to the power of 24, equals 16,777,216.

The circumference of Earth is 40075km... If you think of Earth as a giant wheel, you would need a pin spacing of 2.4 meters around the full circumference of the wheel to equal this number of bit combinations.

Another way of looking at it is, if each tag is randomly programmed when manufactured, you could line up 24 people and get each one to toss a coin, '1' for heads '0' for tails...the chance of one of the combinations being repeated again is one in 16,777,216... If the coins are tossed once every minute the probability of repeating the same combination again would take 32 years...

I think you will agree that 24 bits are more than enough to ensure good security for this project!



The 'works' of the RFID tag is tiny, as this photo shows. Very close to actual size, this is the same tag that's encased on the keyring shown above left.

Up to eight tags

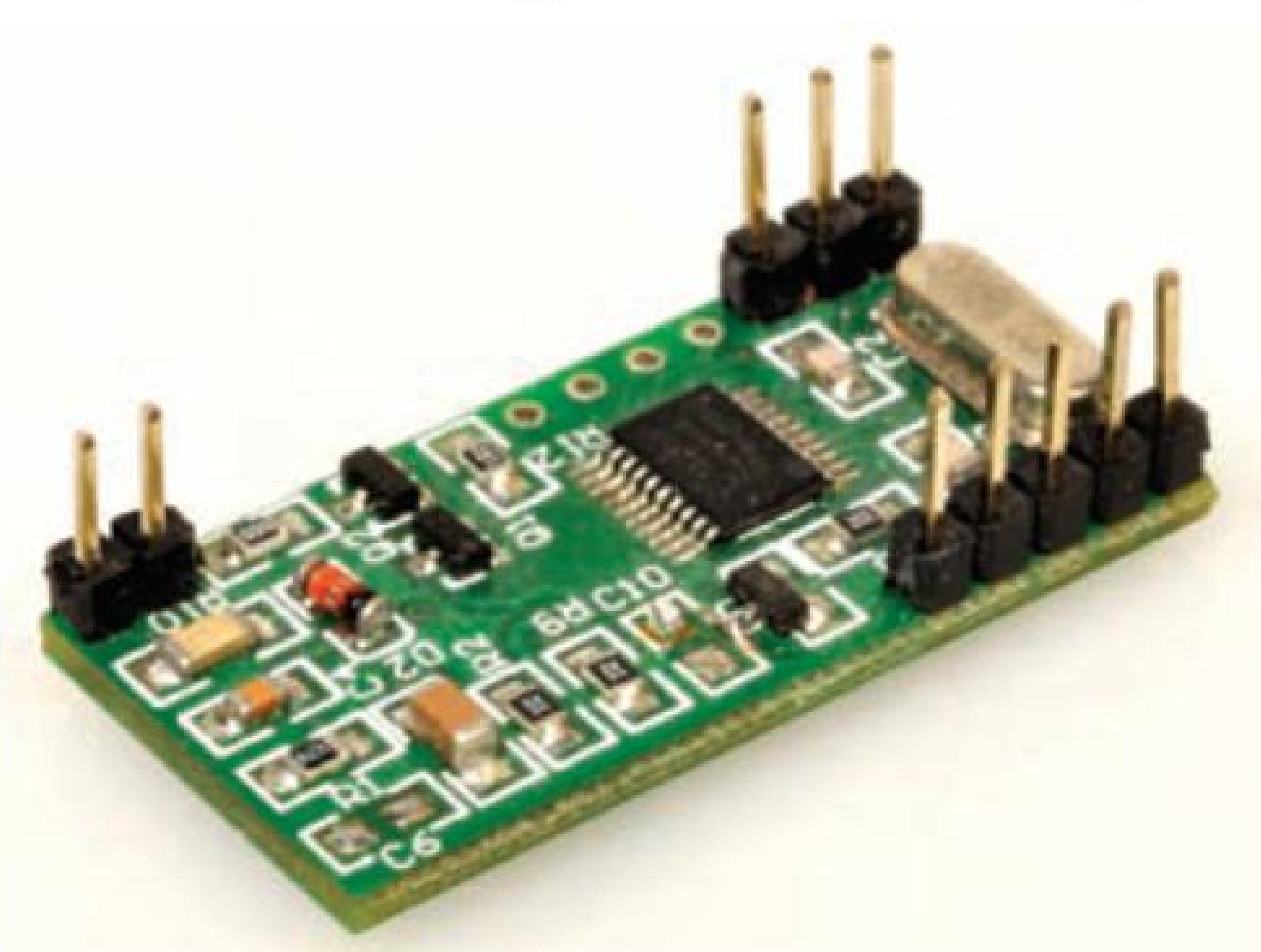
When setting up the system, the user can make the system learn up to eight separate tags. The unique code of each of the tags is then stored in memory. When a tag is detected, the micro compares its code with those in memory. If a match is found, the relay is latched for one second and the GO LED is lit, also for one second. One of the eight user LEDs will also light to indicate which tag was detected.

After the relay unlatches, the system goes back to standby, waiting for the next tag to come by. That is really all there is to the system. The relay can be used to operate an electric door strike to give controlled access to a room or building.

Be careful when selecting the door strike: you can get 'fail safe' where the lock will be open if power is not applied, or 'fail secure' where the mechanism will be locked if power is not applied.

You have the choice of wiring the relay output so power is normally applied and the lock opens when the relay pulls in (wasteful of power, but important if emergency egress is required), or using a fail-secure strike, which 'opens' for the second power is connected (much less wasteful of power, but can be a hazard in an emergency).

The digital output from pin RB2 (IC1 pin 8) can be interfaced to an existing security system so that the RFID system can trigger it, turn on lights and cameras, sound a warning siren and so on. Just



The heart of the project is this RFID module, which comes pre-assembled and tested, ready to solder into the PC board.

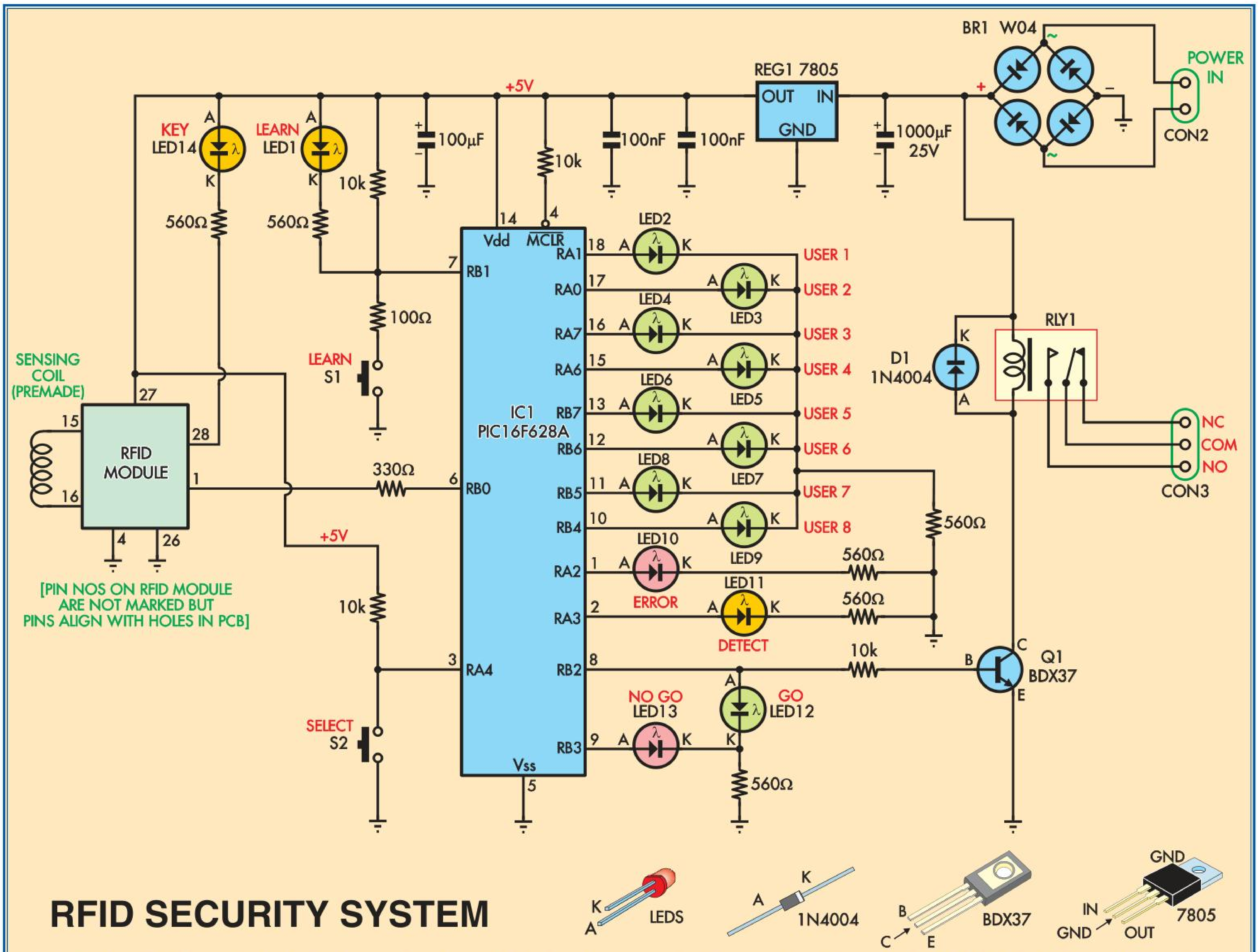

BR1 W04
POWER IN
CON2
REG1 7805
OUT
IN
GND
+5V
1000µF 25V
100nF
100nF
100µF
10k
KEY LED14
LEARN LED1
A
K
560Ω
560Ω
10k
14
4
Vdd
MCLR
7
RB1
RA1
RA0
RA7
RA6
RB7
RB6
RB5
RB4
RA2
RA3
RB2
RB3
LED2
LED3
LED4
LED5
LED6
LED7
LED8
LED9
USER 1
USER 2
USER 3
USER 4
USER 5
USER 6
USER 7
USER 8
RLY1
D1 1N4004
NC
COM
NO
CON3
SENSING COIL (PREMADE)
RFID MODULE
27
28
15
16
1
4
26
330Ω
6
RB0
IC1 PIC16F628A
100Ω
LEARN S1
+5V
10k
[PIN NOS ON RFID MODULE ARE NOT MARKED BUT PINS ALIGN WITH HOLES IN PCB]
LED10
ERROR
LED11
DETECT
560Ω
560Ω
560Ω
10k
Q1 BDX37
3
RA4
8
9
NO GO LED13
GO LED12
SELECT S2
Vss
5
560Ω
RFID SECURITY SYSTEM
LEDS
1N4004
BDX37
7805
IN
GND
OUT

Fig.2: the RFID module detects any tag brought into close proximity, sending its code to IC1. This in turn determines whether it is a valid code and if so, energises the relay for about a second.

The one-second relay closure is perfectly suited to a central locking controller, or an electric door strike, such as this one (available from Jaycar and Altronics). Bear in mind our comments about fail-safe and fail-secure electric strike models.

keep in mind that the relay only pulls in for a second, so any other device will need to take this into account.

The system will operate on 12V DC, so it can be used to operate a car central locking system. The scanning coil could be placed up against the inside of the windscreen and the relay connected to the car's locking system. This would give a high level of security to your vehicle.

I'm sure that readers will come up with a few other applications for this system.

Indeed, the 8-user LED outputs can also be used to perform various functions – with some clever interfacing the eight user LEDs can be used to give varying levels of security.

As an example, user 1 may be given full access to a secure building. Users 2 and 3 may only be allowed access to certain rooms. Despite its apparent simplicity, the project presented here could form the basis of a very secure personnel access control system.

How it works

The RFID Security System circuit diagram (Fig.2.) shows that there are not a lot of components in this system – if we take away the mandatory power supply there is not much left. The actual receiving of the data is done by a pre-built module. The output from this module is a 42-bit data frame, but as explained earlier, we only use the last 24 bits. The micro extracts this 24-bit data, then compares this with the eight memory locations and if a match is found the relay is latched for one second and the activated User LED is turned on for one second.

The ERROR LED will light if a tag was detected, but its code was not complete or corrupted in some way.

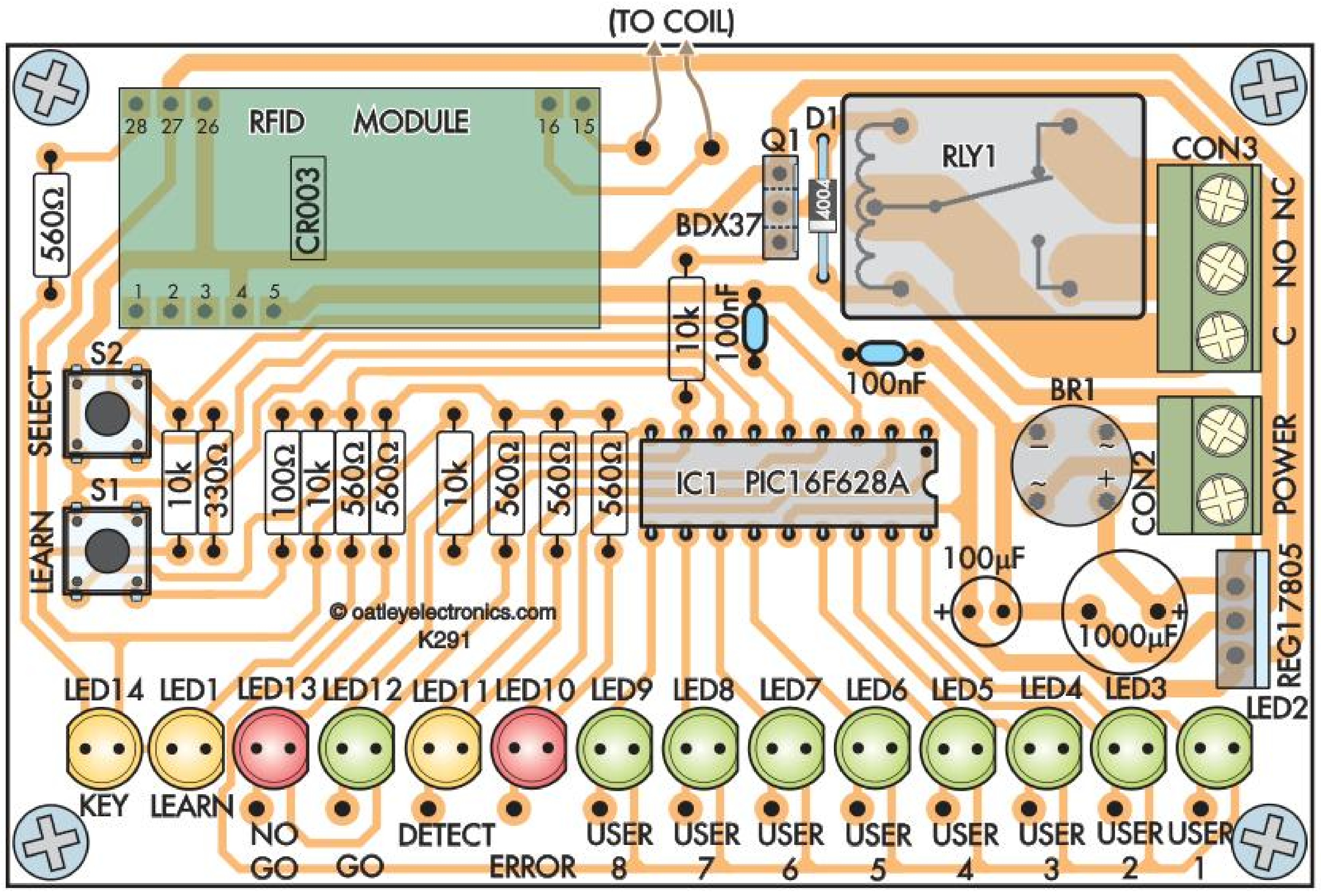
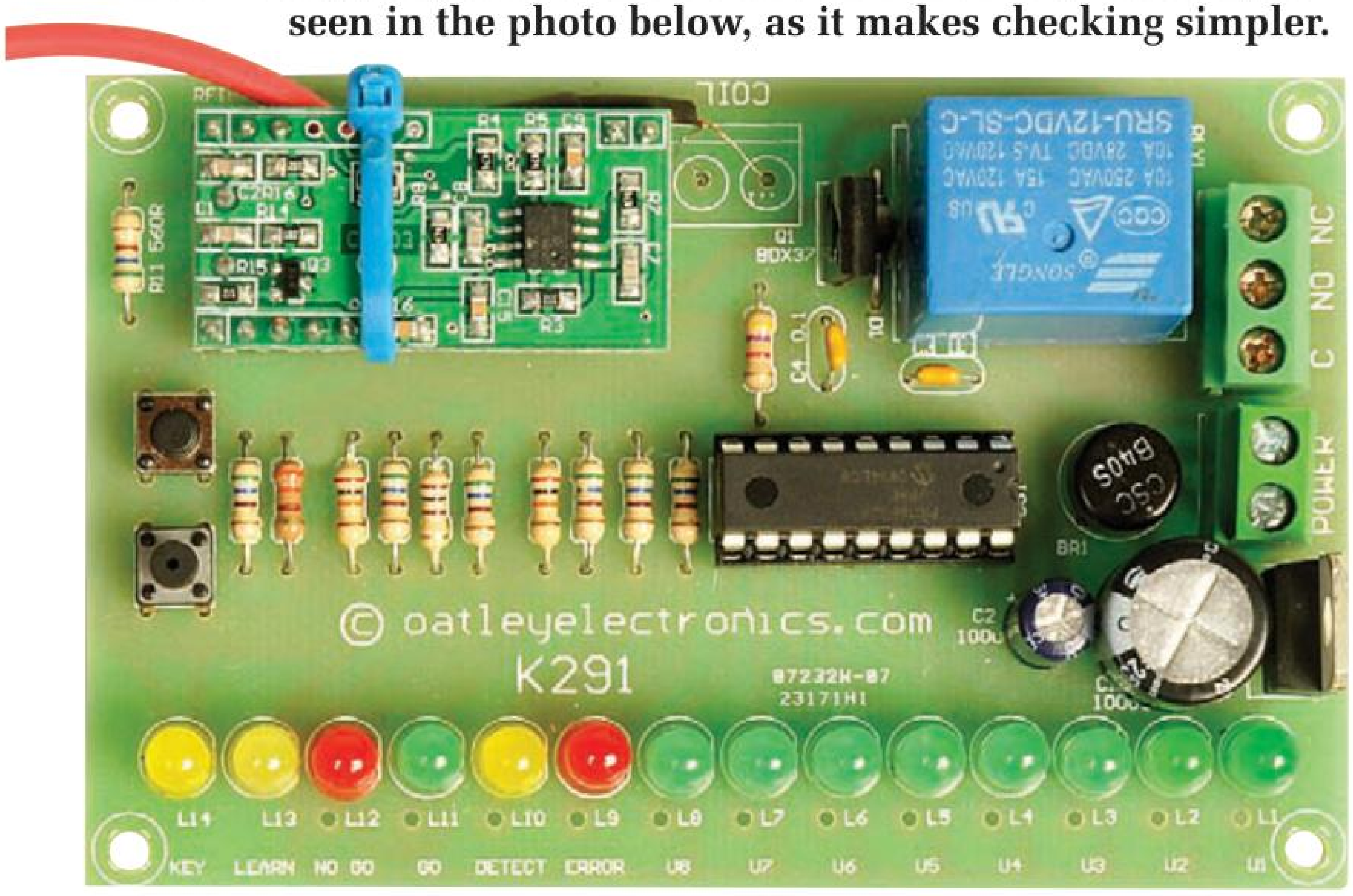

(TO COIL)
28 27 26 RFID MODULE 16 15
1 2 3 4 5
CR003
560Ω
Q1
D1
BDX37
4004
RLY1
CON3
NO NC
C
10k
100nF
100nF
BR1
S2
SELECT
S1
LEARN
10k
330Ω
100Ω
10k
560Ω
560Ω
10k
560Ω
560Ω
560Ω
IC1 PIC16F628A
CON2
POWER
100µF
1000µF
REG1 7805
© oatleyelectronics.com
K291
LED14 LED1 LED13 LED12 LED11 LED10 LED9 LED8 LED7 LED6 LED5 LED4 LED3 LED2
KEY LEARN NO GO GO DETECT ERROR USER 8 USER 7 USER 6 USER 5 USER 4 USER 3 USER 2 USER 1

Fig.3: follow this component overlay as you construct the RFID Security System. Note LED 14 faces the opposite way to the other LEDs. We suggest you use an IC socket for the PIC processor, as seen in the photo below, as it makes checking simpler.


© oatleyelectronics.com
K291

PARTS LIST – RFID Security System

1 PC board (code 875) available from the *EPE PCB Service*, size 96mm × 62mm
*1 CR003 pre-built RFID receiver module (supplied with pre-made sensing coil to suit)
1 2-way PC-mount screw terminal, 5.08mm spacing **(POWER – CON2)**
1 3-way PC-mount screw terminal, 5.08mm spacing **(RELAY OUT – CON3)**
*1 SPDT 12V relay, PC-mounting
2 tactile switches, PC-mounting (S1,S2)
1 18-pin DIL IC socket

Semiconductors
*1 PIC16F628A microprocessor (programmed with RFID_4.hex) (IC1)
1 7805 5V three terminal regulator (REG1)
1 W04 bridge rectifier
1 BDX37 *NPN* transistor Q1
1 1N4004 silicon diode D1
14 5mm LEDs of any colour (LED7-LED14)

Capacitors
1 1000µF 25V radial electrolytic
1 100µF 25V radial electrolytic
2 100nF monolithic

Resistors (0.25W, 5%)
4 10kΩ
6 560Ω
1 330Ω
1 100Ω

WHERE DO YOU GET IT?

This design and its operating software are copyright © 2010 Oatley Electronics.

A kit of parts for this project, with all components listed above, is available from Oatley Electronics (Cat K291). *www.oatleyelectronics.com (including 10 keyring RFID tags).

**Any technical enquires for this project should be directed to jeffmon@optusnet.com.au
Phone support is not available for this project. All enquires and questions will be answered via this email address.**

The DETECT LED lights to show a tag was detected and decoded.

The power supply is about as standard as you can get, with a bridge rectifier followed by the standard big filter capacitor, 3-terminal 5V regulator and then a 100µF output filter capacitor. The two 100nF caps help to keep the supply rail quiet and are placed near the microprocessor.

Pushbutton switch S1 and associated components, along with the learn LED, are used in the tag storage function. Pin 7 (RB1) of IC1 can be both an input and an output. Normally, the pin is an input and the learn LED is off. The PIC micro polls this pin, looking to see if the Learn pushbutton (S1) is pressed at any time. When it is pressed, the input pin is changed to an output which is then pulled low. What this does is to hold the Learn LED on after the button is released. This now means that the system is in learn mode.

Learning the tags

Before this system can work effectively it must learn at least one tag so that it will have something to compare any detected tags with.

To learn tags, the operator presses and releases the learn button, S1. The Learn LED will now come on and stay on, as previously stated. The program is now in learn mode and waiting for the next tag to come along. The operator now simply places the tag to be stored near the receiving coil. If the program successfully decodes this tag the learn LED will go out and user 1 LED will come on.

The system is now waiting for the user to select a memory location for the next tag.

Pressing the USER SELECT button (S2), will cause the user LEDs to cycle round. First press will turn user 1 LED off and user 2 LED on. Next press will turn user 2 LED off and user 3 LED on. Each press of the select button will shift along the LEDs. When LED 8 comes on, the next press will cycle back to user 1 LED.

When you are happy with the memory location, press the learn button (S1) again. The last decoded tag will now be stored in the memory location indicated by the user LEDs.

The LEARN LED will now flash once. The program now stores the unique tag ID in EEPROM.

That's it, the tag has been saved. When the same tag is decoded next time, the system will respond and allow access to the user holding that tag.

To erase any memory location the operator simply goes through the same procedure and stores the new tag over the top of what was stored in the old memory location.

To summarise the tag-learning procedure, users should consult the following table:

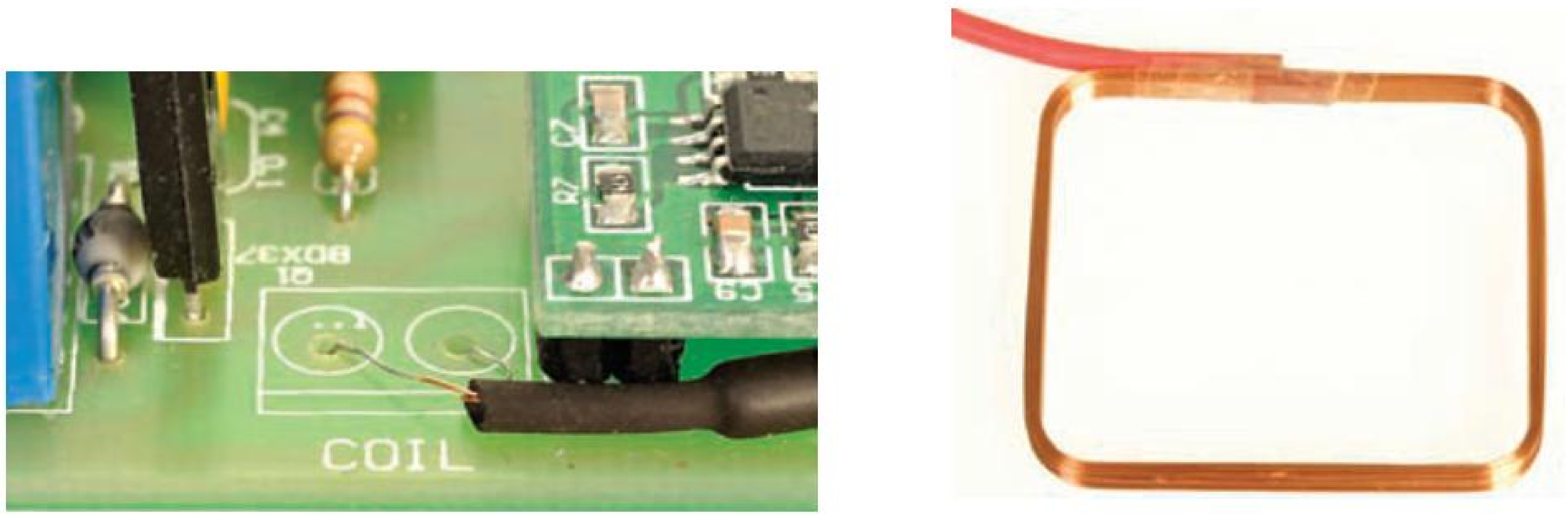
ACTION	RESULT
Press and then release the LEARN button (S1)	Learn LED on
Bring required RFID tag in range of coil	Learn LED off User 1 LED on
Select memory location with SELECT button (S2)	User LEDs shift along
When location selected press LEARN button	Tag stored in user location

The Tag has now been detected, decoded and stored in the User EEPROM location.

Construction

Assembly of the project is fairly straightforward. The PC board is of a very high quality; as long as your soldering is up to the task and the components are placed in the correct position you are virtually assured of an operational project. The PC board will be available from the *EPE PCB Service*, code 875.

Start construction by inserting the resistors and capacitors on the PC board. Remember that the electroylitic capacitors are polarised, so be careful when installing them. The same goes for the LEDs.



The sensing coil (shown close-up at right) solders directly to the PC board alongside the RFID module. This coil, which measures about 50mm × 45mm, is made from very fine wire, so it needs to be treated with care. The ends of the coil wires pass through a protective spaghetti sleeve to protect them.

There is a trap for careless players with the LEDs: all bar one mount flat side (cathode (K)) to the right, when looking at the board with the terminal blocks on the right. LED 14 mounts cathode to the left. You have been warned!

It is recommended that an IC socket be used for the microprocessor – again, this must go in the right way around. The RFID module should be installed next and again be extra careful when handling this component.

The bridge rectifier, 3-terminal regulator and transistor are next, and all three are polarised (no heatsink is needed on the regulator). The relay is the last on-board component and will only go in one way.

Sensing coil

The sensing coil is supplied pre-assembled, which means you only need to attach it to the PC board.

However, the wire which forms the coil is quite fine and will be easily damaged with any form of rough handling. There's about 200mm of wire emerging from the coil – this attaches to the two points marked 'COIL' on the PC board (polarity is unimportant).

To protect this fine wire, we slid on a piece of thin heatshrink tubing over the two wires (which are in fact loosely twisted together) and glued it to the coil itself (the coil is actually quite rigid).

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To prevent stress on the opposite ends of these wires (ie, the end where they solder to the PC board), we anchored the heatshrink with a small cable tie right around the RFID module and heatshrink

You also need to decide whether you're going to have the coil close to the PC board or some distance away.

If you mount it any further away than the ~200mm allowed by the connecting wires, you'll need to extend them with either thin insulated hookup wire or better still, two strands of ribbon cable or some thin Figure-8 cable.

Note that we have not tested the RFID unit with the coil any further away than the 200mm. In theory, it should be quite OK but...

Smoke test

At this stage, do not install the microprocessor. Apply power and using your multimeter measure the voltage on pin 14 with respect to pin 5 of the micro. You should read close to 5V DC. If OK, then switch off the power, wait for a short while and then install the microprocessor.

This time, when you switch on the power the LEARN LED should come on for 500ms.

If this happens, then the system is alive and well and ready for work.

One of the first things the program does is to load the eight user IDs from EEPROM so it is ready to decode the stored tags.

If no user data has been stored in EEPROM the unit will ignore all tags. Go through the learning tag procedure to store at least one tag. ***EPE***

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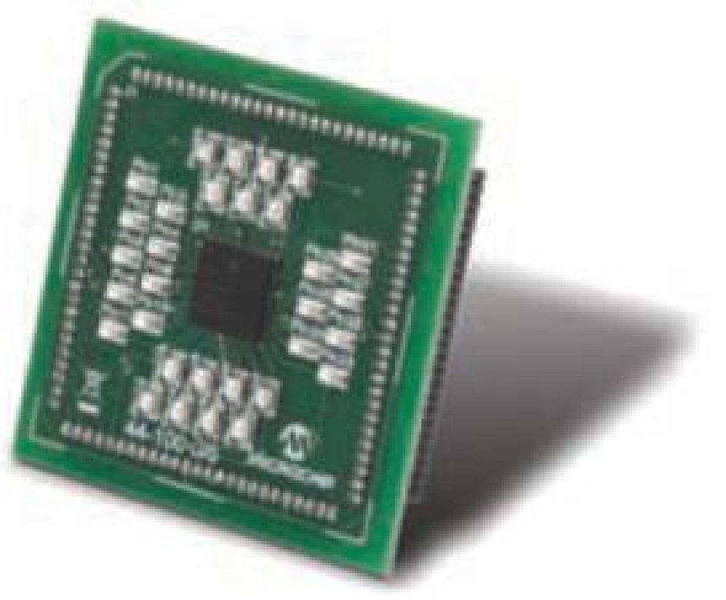

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EASY USB *plus* TELESCOPE DRIVER CONTROL

By Martin Crane

The purpose of this article is two-fold: to describe a relatively new and possibly unique product called 'Easy USB' by Brunning Software, which makes programming serial USB communication applications between your PC and a PIC-based peripheral simple. We also consider, as a practical example, how this method can be used in, the development of an astronomical telescope drive system.

MODERN operating systems coupled with 'USB only hardware' can be problematic for home-based DIY electronic projects, even if it's the additional cost of a USB to serial port converter. This is particularly true of modern laptops, as they rarely have a serial port fitted. 'Easy USB' is a very useful addition to Brunning Software's training package for PIC and PC serial-based communication.

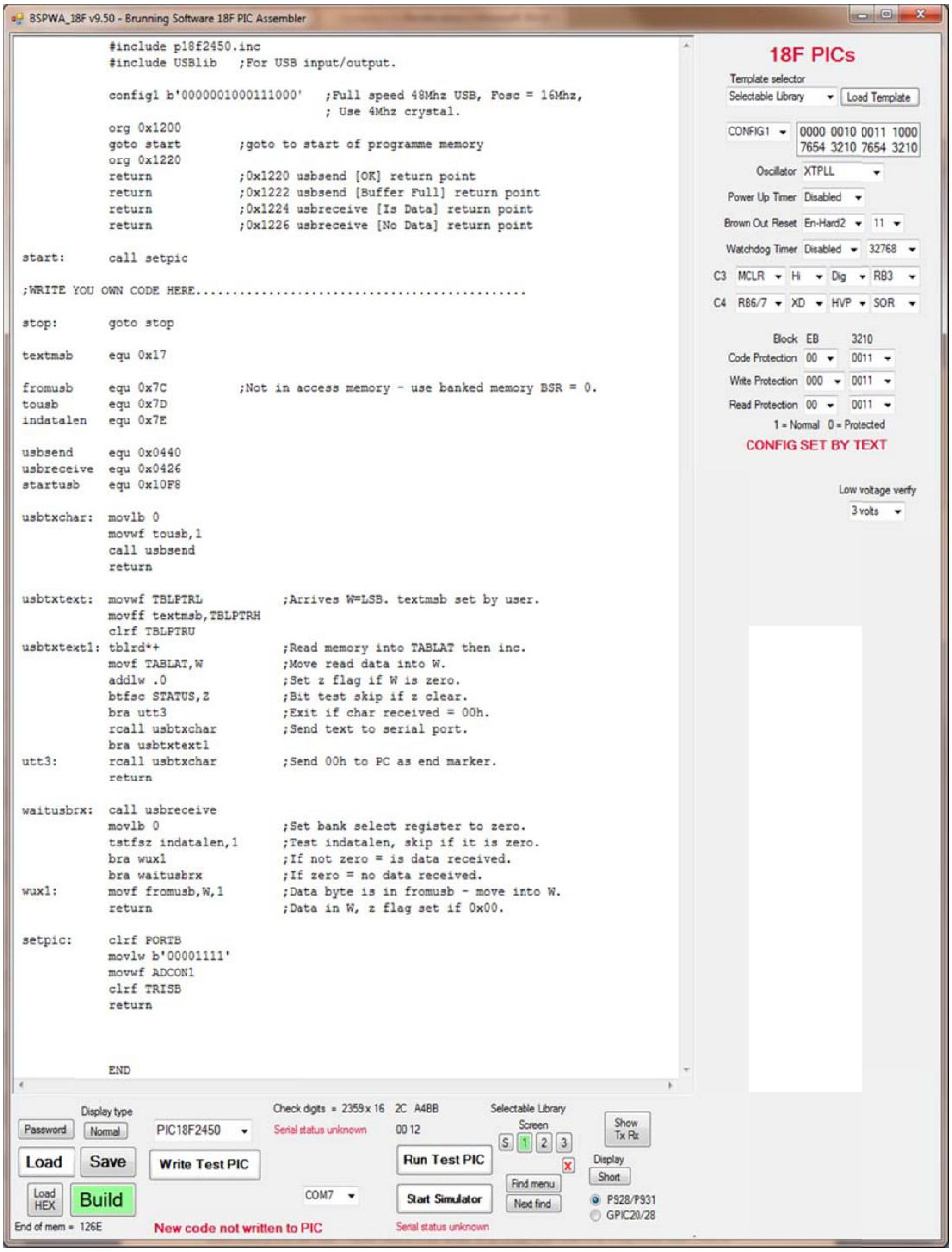
The beauty of it being that you can use Microchip's 18F range of USB-enabled PIC's, but without any of the complexities that a fully enabled USB communication link involves; you simply write your PIC assembler and PC Visual C# code exactly as if you were using a simple serial port. The USB-to-serial-port converter now becomes part of the PIC circuit.

How does 'Easy USB' work?

Brunning software's P931 training package includes a new version of BSPWA – a combined text editor, code builder and programming application, a new all USB combined test module and production PIC programmer, and an updated *Experimenting with Serial Communication* book.

BSPWA_18F version 9.50 (Listing 1) has two built in library routines, one to receive data, the other to send data. Based on a USB PIC 18F2450, you load, from within BSPWA, a built-in template into the text editor that includes calls to the USB libraries which lay hidden behind the scenes.

Only the critical entry and exit points to the PIC USB code are provided, **usbsend** and **usbreceive**, plus three variables to hold data, **tousb**, **fromusb** and **indatalen**. The USB libraries occupy PIC memory up to address 0x11FF, so your program must start at address 0x1200. Apart from this, you would barely know it existed. When you build and write your code to the PIC, the unseen USB code is automatically included.



BSPWA_18F v9.50 - Brunning Software 18F PIC Assembler

```
            #include p18f2450.inc
            #include USBlib   ;For USB input/output.

            config1 b'0000001000111000'   ;Full speed 48Mhz USB, Fosc = 16Mhz,
                                          ; Use 4Mhz crystal.
            org 0x1200
            goto start        ;goto to start of programme memory
            org 0x1220
            return            ;0x1220 usbsend [OK] return point
            return            ;0x1222 usbsend [Buffer Full] return point
            return            ;0x1224 usbreceive [Is Data] return point
            return            ;0x1226 usbreceive [No Data] return point

start:      call setpic

;WRITE YOU OWN CODE HERE.............................................

stop:       goto stop

textmsb     equ 0x17

fromusb     equ 0x7C          ;Not in access memory - use banked memory BSR = 0.
tousb       equ 0x7D
indatalen   equ 0x7E

usbsend     equ 0x0440
usbreceive  equ 0x0426
startusb    equ 0x10F8

usbtxchar:  movlb 0
            movwf tousb,1
            call usbsend
            return

usbtxtext:  movwf TBLPTRL           ;Arrives W=LSB. textmsb set by user.
            movff textmsb,TBLPTRH
            clrf TBLPTRU
usbtxtext1: tblrd*+                 ;Read memory into TABLAT then inc.
            movf TABLAT,W           ;Move read data into W.
            addlw .0                ;Set z flag if W is zero.
            btfsc STATUS,Z          ;Bit test skip if z clear.
            bra utt3                ;Exit if char received = 00h.
            rcall usbtxchar         ;Send text to serial port.
            bra usbtxtext1
utt3:       rcall usbtxchar         ;Send 00h to PC as end marker.
            return

waitusbrx:  call usbreceive
            movlb 0                 ;Set bank select register to zero.
            tstfsz indatalen,1      ;Test indatalen, skip if it is zero.
            bra wux1                ;If not zero = is data received.
            bra waitusbrx           ;If zero = no data received.
wux1:       movf fromusb,W,1        ;Data byte is in fromusb - move into W.
            return                  ;Data in W, z flag set if 0x00.

setpic:     clrf PORTB
            movlw b'00001111'
            movwf ADCON1
            clrf TRISB
            return



            END
```

18F PICs

Template selector: Selectable Library

CONFIG1: 0000 0010 0011 1000 (7654 3210 7654 3210)

Oscillator: XTPLL

Power Up Timer: Disabled

Brown Out Reset: En-Hard2, 11

Watchdog Timer: Disabled, 32768

C3: MCLR, Hi, Dig, RB3

C4: RB6/7, XD, HVP, SOR

Block: EB, 3210

Code Protection: 00, 0011

Write Protection: 000, 0011

Read Protection: 00, 0011

1 = Normal 0 = Protected

CONFIG SET BY TEXT

Low voltage verify: 3 volts

Display type: Normal

PIC18F2450

Check digits = 2359 x 16 2C A4BB

Serial status unknown

00 12

Selectable Library

COM7

End of mem = 126E

New code not written to PIC

Serial status unknown

Display: Short

● P928/P931
○ GPIC20/28

Listing.1: Programming interface and demonstration screen for PIC assembler version BSPWA_18F v9.50 from Brunning

It works remarkably well, as long as the PC controls the PIC, and the USB receive routine is regularly called by your program code to keep the USB link active. Brunning suggests calling the routine at least once every 0.5 seconds. Although my experiments show that longer is possible. This is ideal for projects of simple-to-medium complexity, where, for example, you might regularly send a byte of data from your PC instructing the PIC to perform a short routine, such as set the state of PORTB.

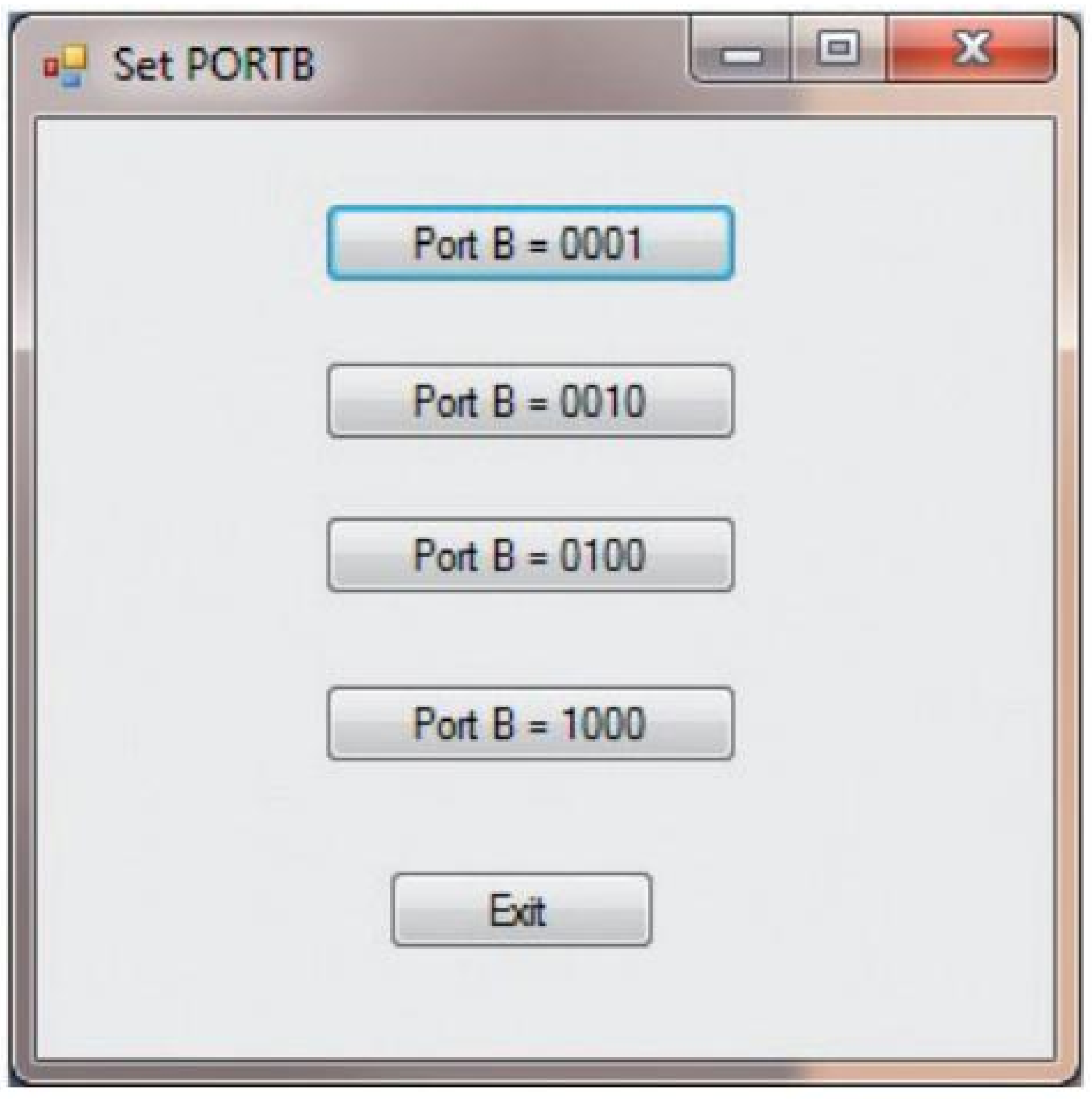


Fig.1. Setting the state of PORTB

'Easy USB' example

The PIC reads a byte sent form the PC, the output is set accordingly, and the program returns to regularly calling the USB receive routine and waiting for the next instruction.

A simple PC to PIC Easy USB example to turn on four LEDs attached to PORTB, is shown in Fig.1.

The minimum Visual C# code, minus any error checking or exception handling is given in Listing 2.

The corresponding PIC assembler code is outlined in Listing 3 (see software panel).

'Easy USB' limitations

Timing may become a problem for more complex projects, such as my proposed telescope driver circuit, where for example, the PC will ultimately issue an instruction to 'Go to' a given position and take several seconds to get there. I used stepper motors to slew the telescope and encoder feedback for position control.

Imagine that to slew from 'A' to 'B' requires the stepper motor to gently ramp up to a certain speed, ramping back down as it approaches the desired position and finally stopping when the encoder count matches the requested position. Depending upon the length of slew, this will take several seconds. During this period, calling the USB receive routine will have been neglected.

So what is the solution? Placing the USB receive call in the delay between motor steps is perfectly possible, but how long does calling the USB receive routine actually need, will it take longer than the required delay and is this equal for all PC's? It would probably be fine if timing or counting were not important.

However, I need to monitor encoder counts during the motor routine. Using interrupts is an option, but can get complicated, and I prefer avoiding this where possible.

The difficulty is partly due to the structure of the USB PIC compared to a PIC with a standard USART, with the latter being controlled by the PIC itself. The USB PIC is effectively two PICs in one.

Fortunately, Brunning Software's *Experimenting with Serial Communication* book contains a simple solution for more complex projects, or projects where timing is critical. It is simply to use a PIC 18F2450 as a USB-to-USART converter. A circuit diagram is provided and BSPWA contains a built in template that can be loaded, compiled and written to the PIC, without you even having to type a line of code.

USB-to-USART converter example

The converter's USART can connect to any other PICs USART. In fact, you can connect up to 10 PICs to the single USB\USART converter, thus introducing the concept of an addressable communication bus where all PICs receive the same instruction, but only PICs programmed to accept a particular instruction act on it, see Fig.2. Now that PICs are so reasonably priced, it's a wonderful method to use for a complicated project.

The main advantage of this method code-wise, is that because the PIC directly controls its own USART you can simply test the peripheral interrupt register (PIR1) by checking the state of the USART Receive Interrupt Flag (RCIF) to see if data has been received. If RCIF = 1, then the receive buffer is full; if RCIF = 0 the buffer is empty. So, at any point in your program you can use **btfss pir1,rcif** or **btfsc pir1,rcif** to check if new data has been sent by the PC.

For 16F PICs these instructions take 1 PIC clock cycle if not true and 2 cycles if true. For 18F PICs 3 cycles are taken if true if the next instruction is a **goto**. As this whole routine is contained within the PIC, then timing is easily controlled.

In Fig.2, the 18F2450 is the USB\USART converter, programmed using the aforementioned option in BSPWA. PIC 'A' and PIC 'B' are 16F870s, but could be virtually any PIC with a USART. PORTA is configured for digital input, PORTB for output, and the USARTs are setup for 9600 baud rate, as shown in Listing 4.

Reconsider the application shown in Fig.1, but this time each PIC is programmed with a continuous on\off flashing routines. Now let us say you wish 'PIC A' to respond when sent bytes 0x01 and 0x03 (odd bytes), but you wish 'PIC B' to respond when sent 0x02 and 0x04 (even bytes). Because we are now using the USB\USART converter to keep the USB link active, the PIC routines can flash the LEDs indefinitely, but respond to a change command at any time.

The Visual C# code remains unchanged. The PIC code will alter slightly for each PIC.

Both 'PIC A' and 'PIC B' need to include the routines contained in Listing 5.

The programme code for 'PIC A' is contained in Listing 6.

The programme code for 'PIC B' is contained in Listing 7. (See software panel).

TELESCOPE DRIVER CONTROL SYSTEM

This is not primarily an astronomy article. It describes my efforts (work in progress) to use PIC and PC programming to design my own drive system with the ultimate aim of being able to click on a star chart's object displayed on the screen, resulting in my telescope slewing to that position and then continuing to track that object, while awaiting the next instruction.

Yes, I know there are many commercial telescopes that can interface to your PC, phone or iPad and do it all for you, but that's not the point. I must admit the concept of using such a device actually mounted on my telescope also doubling up as a 'finder scope' has a certain appeal, but I'd like to achieve something similar myself. Satisfaction aside, projects that you produce and build yourself can easily be modified, improved and added to later.

I've always had an interest in astronomy, as well as electrical/electronic and mechanical engineering. This led me, a few years ago, to build a Newtonian telescope with an 8-inch primary mirror. It was a Dobsonian design built from plywood and manually manoeuvred.

Optically it functioned well, but I tired of the constant 'nudging' it required to track the object being observed while our earth rotated. Hence, I stripped out the optics and fabricated an equatorial open fork mount capable of tracking an object and being driven. It's shown in Fig.3 and I still use it today.

The triangular base contains a set of rechargeable NiCad batteries and the drive electronics. It has a hand controller that plugs into the base with four buttons for slewing and a 20-turn trimpot for fine control of the drive rate. It uses PWM to produce the right ascension (east/west) motor drive rate with a small tacho generator on the end of the motor shaft for speed feedback. Two gearboxes reduce the speed several hundred times, finally driving a 1mm shaft pushed between two closely positioned rollers by a spring-loaded bronze plunger, as shown in Fig.4. Via friction, this drives the larger aluminium disc to which the fork mount and actual telescope are fitted. A second DC motor and gearbox drive a worm and wheel gear to adjust the declination (north/south) axis shown in Fig.5. In other words, it's manually set up and operated but when aligned correctly will track a celestial object keeping it in the eyepiece for several hours without adjustment.

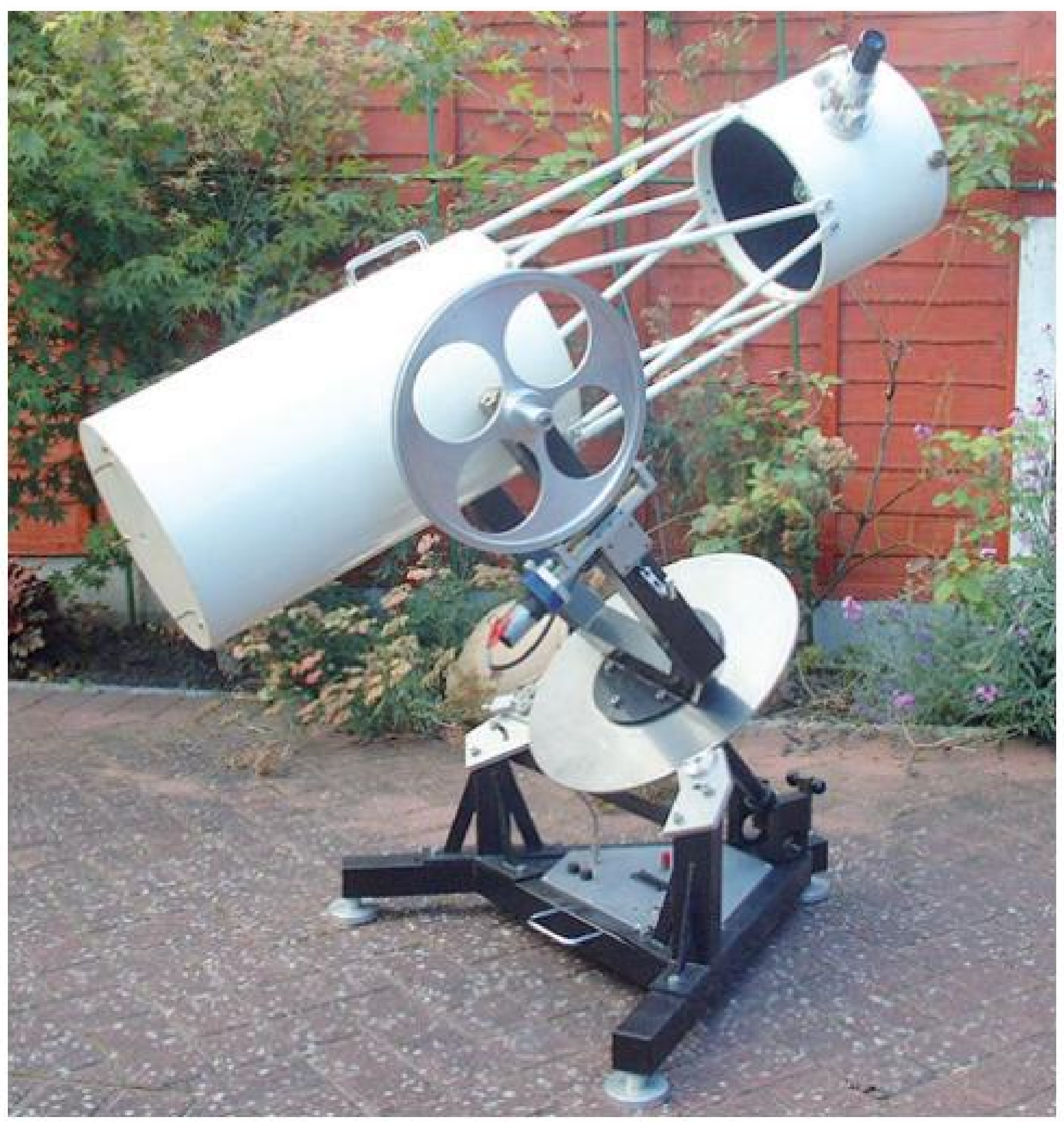


Fig.3. The author's current telescope

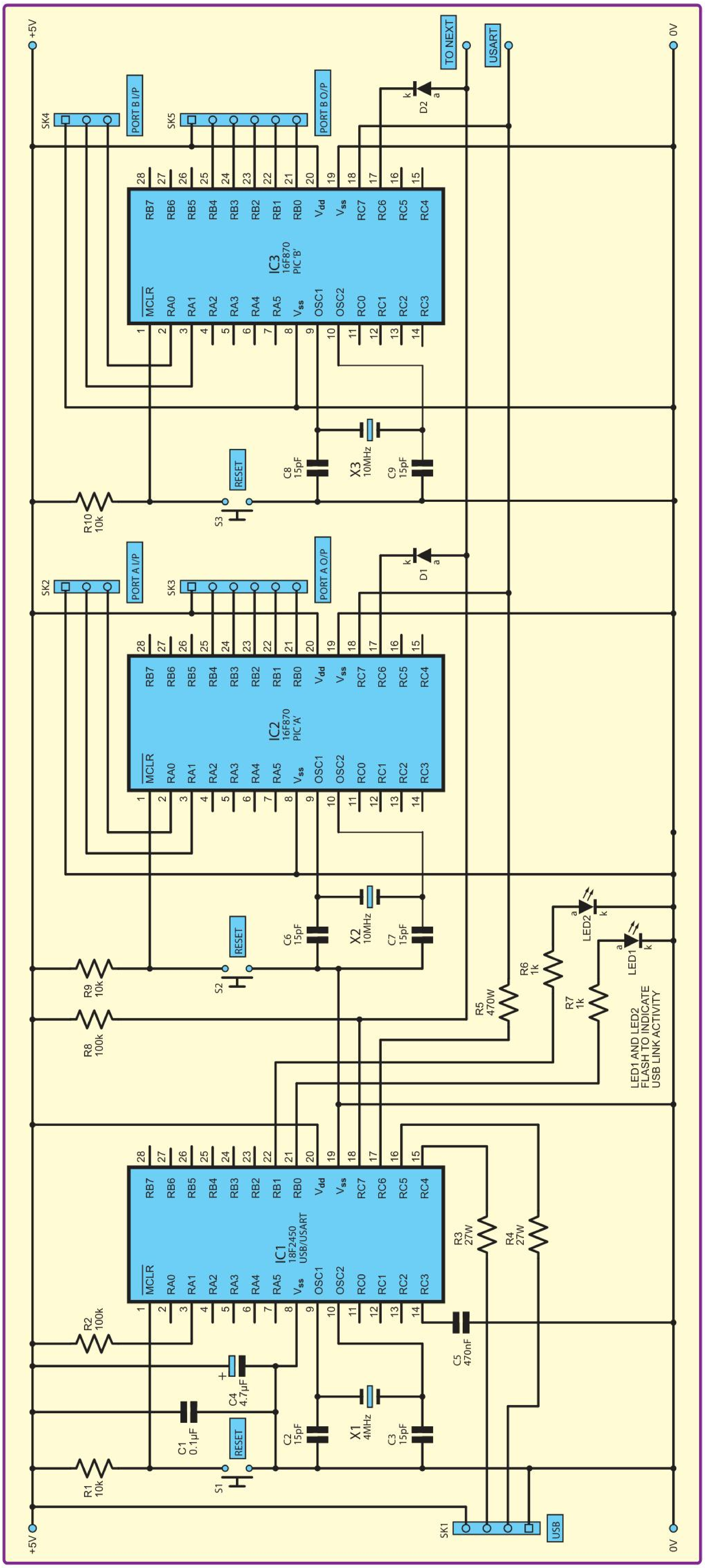

+5V
0V
TO NEXT
USART
SK4
PORT B I/P
SK5
PORT B O/P
IC3
16F870
PIC 'B'
D2
SK2
PORT A I/P
SK3
PORT A O/P
IC2
16F870
PIC 'A'
D1
IC1
18F2450
USB/USART
MCLR
RA0
RA1
RA2
RA3
RA4
RA5
Vss
OSC1
OSC2
RC0
RC1
RC2
RC3
RB7
RB6
RB5
RB4
RB3
RB2
RB1
RB0
Vdd
RC7
RC6
RC5
RC4
R10
10k
S3
RESET
C8
15pF
X3
10MHz
C9
15pF
R9
10k
S2
RESET
C6
15pF
X2
10MHz
C7
15pF
R8
100k
R5
470W
R6
1k
R7
1k
LED2
LED1
LED1 AND LED2
FLASH TO INDICATE
USB LINK ACTIVITY
R3
27W
R4
27W
C5
470nF
R2
100k
C4
4.7µF
C1
0.1µF
C2
15pF
X1
4MHz
C3
15pF
R1
10k
S1
RESET
SK1
USB

Fig.2. USB to USART circuit diagram. Where all PICs receive the same instruction, only those programmed to accept a particular instruction act upon it

Computer control

For my computer control project I've decided to utilise parts I already had. To date, I've built a tube assembly and focuser based on a 16-inch mirror. The primary mirror cell, together with the head containing the secondary mirror and focuser can be easily removed for transport. The combined assembly is shown in Fig.6.

I also have a couple of rather interesting heavy-duty 5-pole stepper motors rated at 5V 1.25A. The step angle is 0.72 deg or 0.36 if half stepped, see Fig.7. The encoders are 5V, 600 pulses/rev, the dual channel incremental variety, see Fig.8.

I'd always felt computer control of anything was way beyond my ability and a 'trade' I'd be unlikely to learn. But along the way I gained interest in 'DIY' software development having purchased a training package from Brunning Software. I also enrolled on a superb Java evening course at my local Technical College.

I was hooked, realising the possibilities that lay ahead, the prospect of controlling items that I had the ability to manufacture. Brunning Software books and training courses are like nothing else I've read. These books teach you how to produce really useful applications from totally practical experiments.

As I continued to experiment with PICs, a flyer arrived in the post from Brunning Software, advertising a new training course *Experimenting with Visual C#* and explaining serial communication between PC and PIC. This was something I'd always struggled with, but it was beautifully presented by Peter Brunning. I don't believe Peter ever writes about anything unless he has actually done it himself; a truly important point worth emphasising.

I was further inspired and could see a way towards achieving my original aim. I made a decision to produce the telescope tube and optical assemblies first in order to prove the telescope would perform optically. Until this was correct there was no point continuing. I also figured that I should develop the drive control before building the actual telescope mount, as the design of the latter would largely depend upon the former

The PC aspect

So now that I have a means of achieving PC to PIC communication, how should I go about gathering and sending the relevant data from my PC to a PIC? I could write a C# application to manually enter coordinates from a star chart and then send them to the PIC. However, there is plenty of star chart software available that already has built in capability to interface with commercially produced telescopes. Meade is one such scope manufacturer. Several years ago I purchased some software, Graystel Star Atlas (although there are many others) that has an option for interfacing to the Meade LX range of telescopes, see Fig.9.

Meade also publish their telescope communication protocol and it can be downloaded at: **www.meade.com/support/LX200CommandSet.pdf**

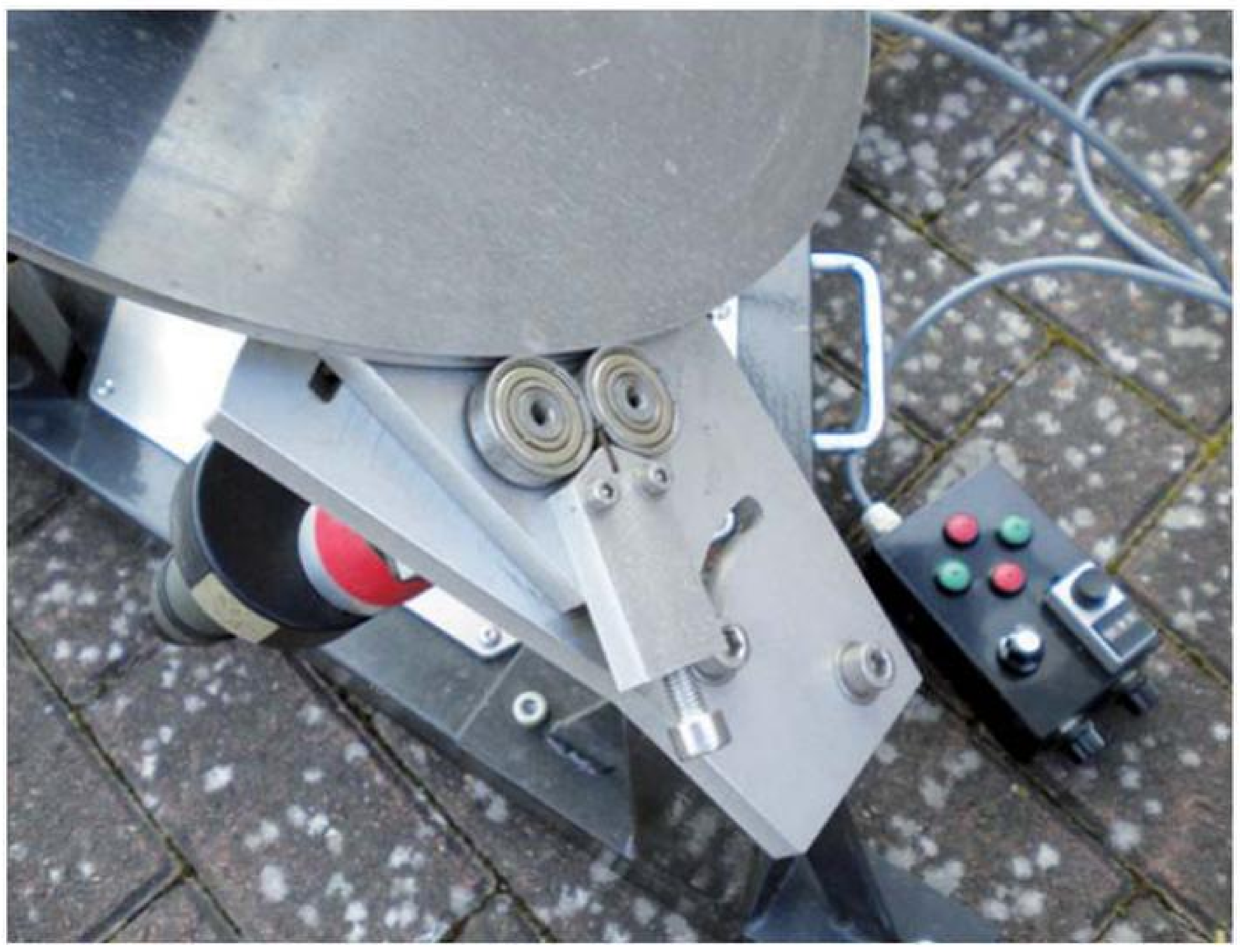


Fig.4. Disc drive arrangement

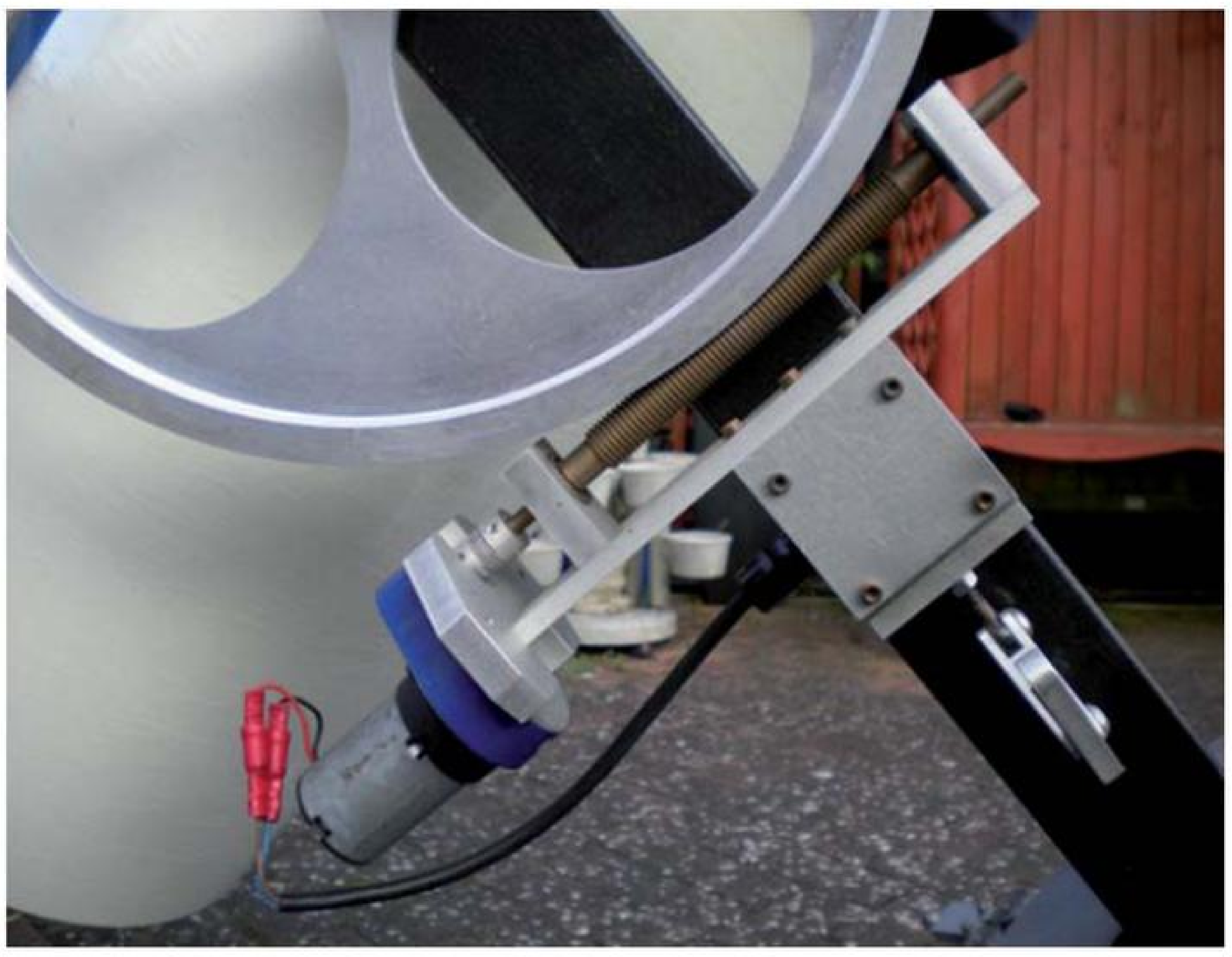


Fig.5. A DC motor and gearbox drive a 'worm' and wheel gear to adjust the north/south axis

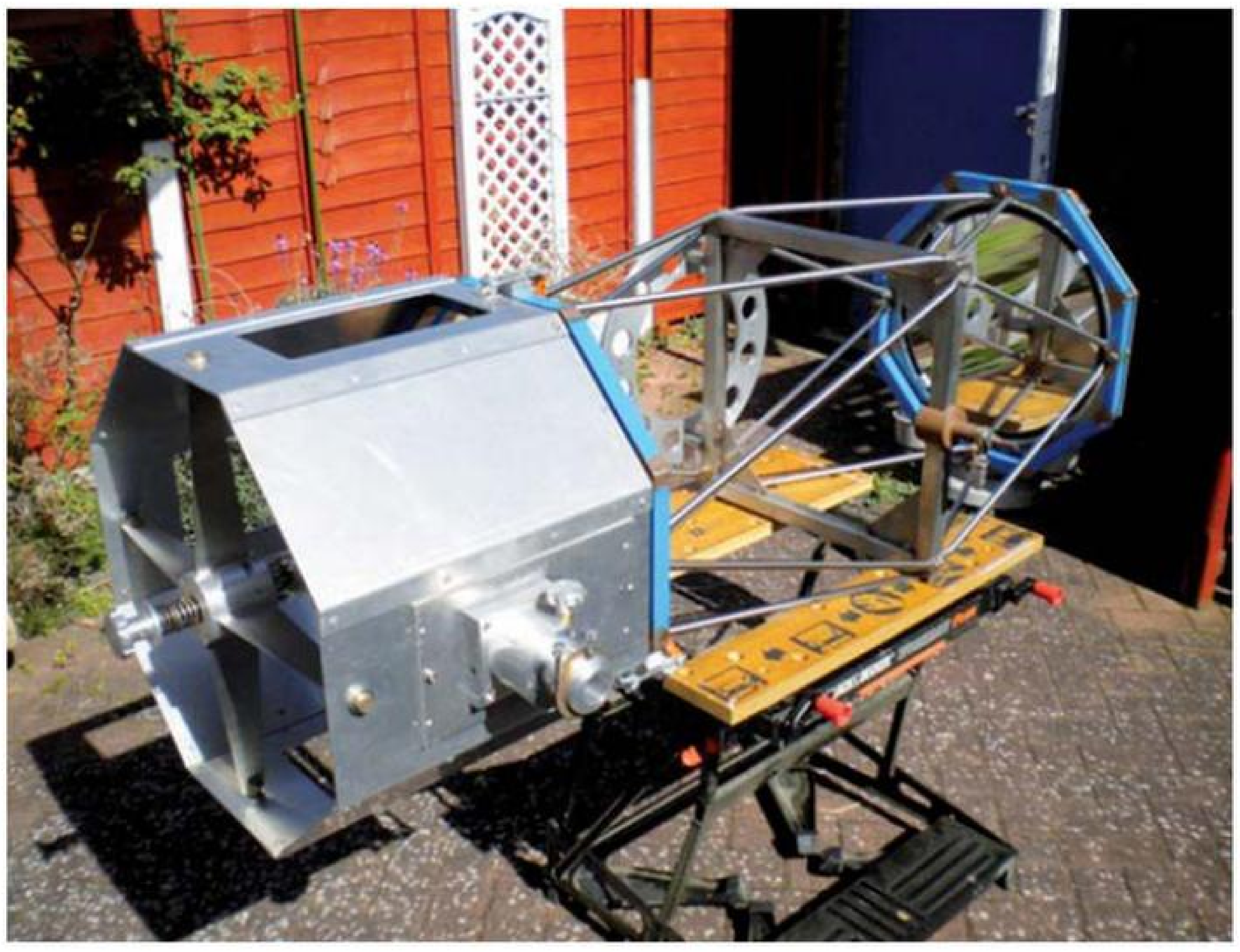


Fig.6. The new 16-inch telescope tube assembly

So this takes care of the PC end of the task quite nicely.

On the chart

Prior to interfacing a telescope to a star chart application, it is typical to 'setup' the telescope first. Traditionally, this involves accurate polar alignment, followed by pointing the scope at one, two or even three known objects and 'telling' the scope where it is, normally 'loading' the relevant coordinates from a table of pre-stored objects from the telescope firmware.

In my case, this would be in PIC program memory. Technically, misalignment can be compensated for in software, but simpler is better, at least to begin with anyway.

Celestial coordinates

It would probably help at this stage to briefly (but not fully) explain celestial coordinates. Just for a moment envision that our earth is a sphere within a much larger sphere. From the surface of our earth we gaze across a void to the inner surface of this far larger sphere. Imagine that this distant surface is not only peppered with the stars that we see, but marked with a grid system similar to our latitude and longitude.

Now further picture that this distant surface is fixed in position while we, the earthbound observer, reside at its centre, rotating about our polar axis. Over and above this, now consider that our earth's polar axis is inclined at 23.5 degrees to the plane of our orbit. Hopefully, Fig.10 will help.

Visualise the earth's equator projected out on to the surface of our imaginary sphere and this line will become the celestial equator in Fig.10. How much we observe above or below the celestial equator relates to our latitude, the date and the time.

The elevation of a star, Point X in Fig.10, is called declination (DEC) and has a positive value above the celestial equator and a negative value below. Much like the Greenwich meridian was chosen to represent our zero reference for longitude, the first point of constellation Aries (point Z) was selected as the celestial zero reference and is represented in Fig.10 by the meridian line from point Z to the northern celestial pole. The angle between the celestial zero meridian and the meridian of star X is called right ascension (RA). RA is measured in hours, minutes and seconds (0 to 23:59:59), from the first point of Aries eastwards along the celestial equator. DEC is measured in (+/-) degrees, minutes and seconds from +90 through 0 to –90.

Position control

Fig.11 represents (for clarity) a six-pulse dual-channel encoder, with Channel 'A' shown in red and Channel 'B' in blue. For six pulses there are 6×4=24 points at which each channel changes state. It's fairly straightforward for a PIC to count these changes.

For direction indication, the best method with a PIC is probably to make use of the encoder quadrature signals. This is achievable because Channel B's output is offset in comparison with Channel A's output. For clockwise rotation comparing AB, the output sequence is 00, 10, 11, 01 etc. For anticlockwise rotation, the AB output sequence is 00, 01, 11, 10 etc. Multiply these sequences of four conditions by the number of encoder pulses to give the total number of condition changes/rev, 24 again.

If you XOR the current value of channel A with the previous value of channel B (or *vice versa*) the result will always equal 0 for clockwise rotation, and equal 1 for anticlockwise rotation. Therefore, it's possible to use the same code to both count pulses and check direction. There was a useful article on the subject of encoders in *EPE* May 2009 entitled *Microstepping Four-Phase Unipolar Stepping Motor Driver*, by Mark Stuart.

Listing 8, the PIC assembler code, can be used to detect direction and count pulses based on connecting channel A to PORTA,0 and channel B to PORTA,1.

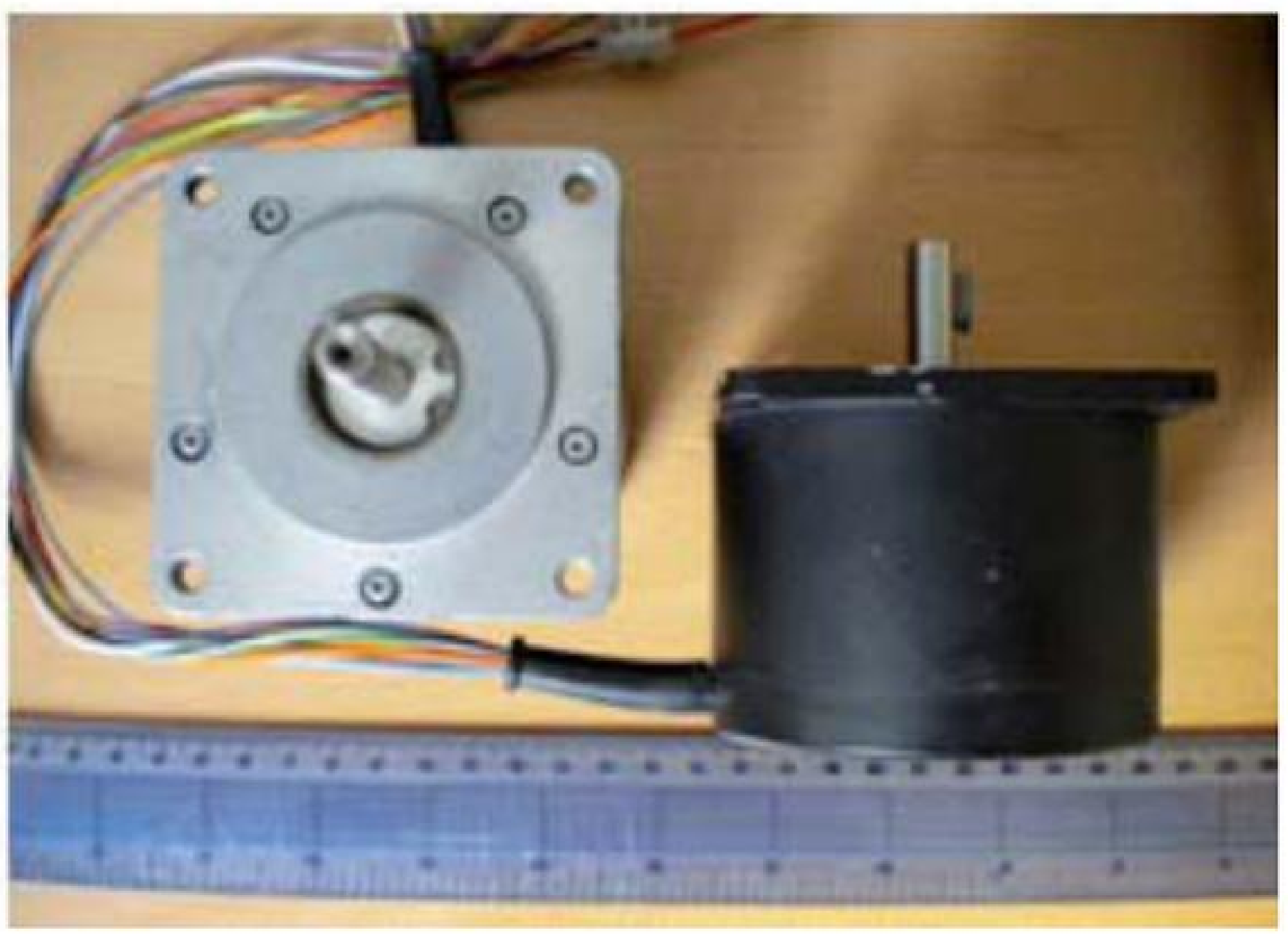


Fig.7. Heavy-duty 5-pole stepper motor

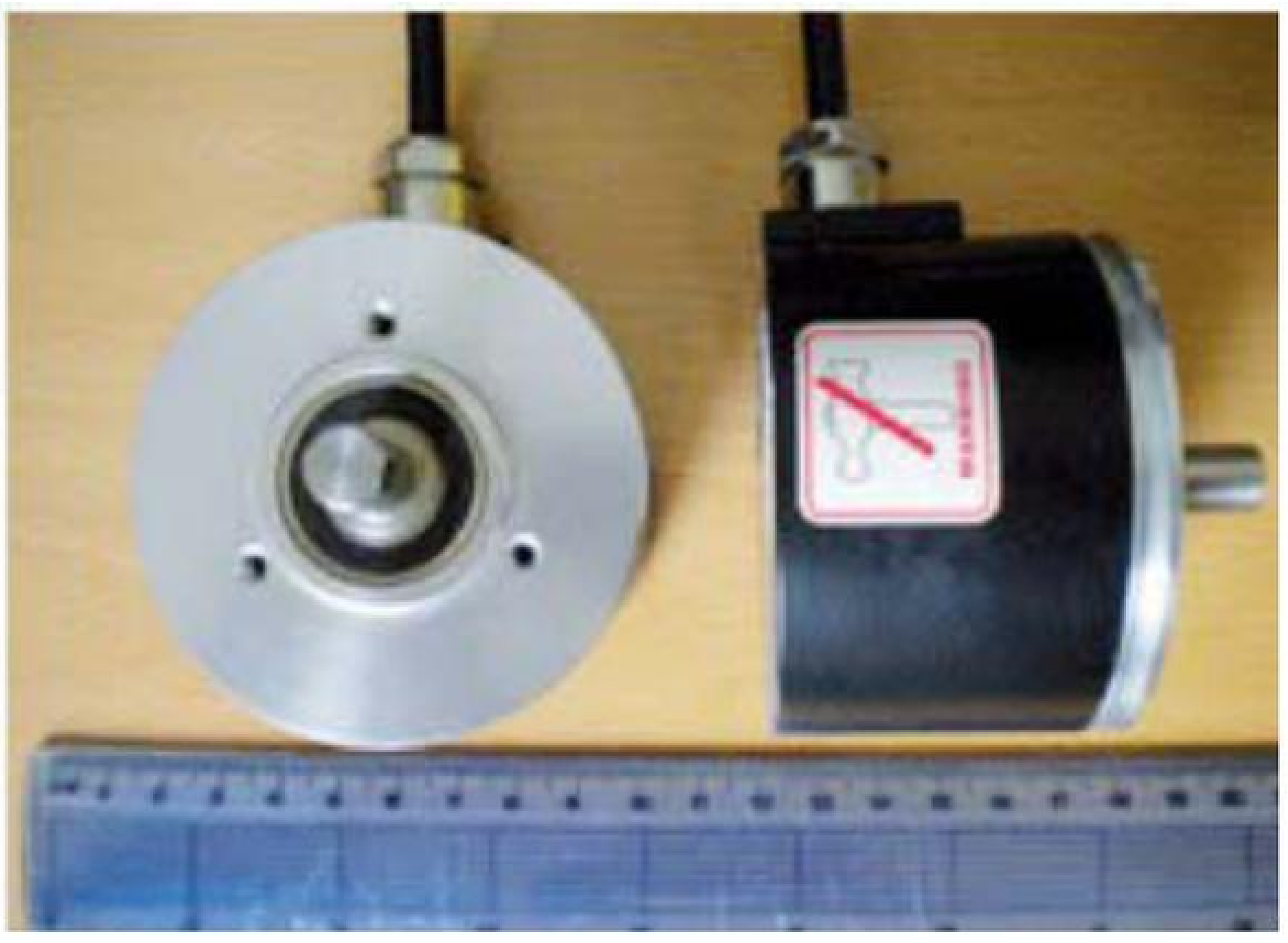


Fig.8. The rotary encoder

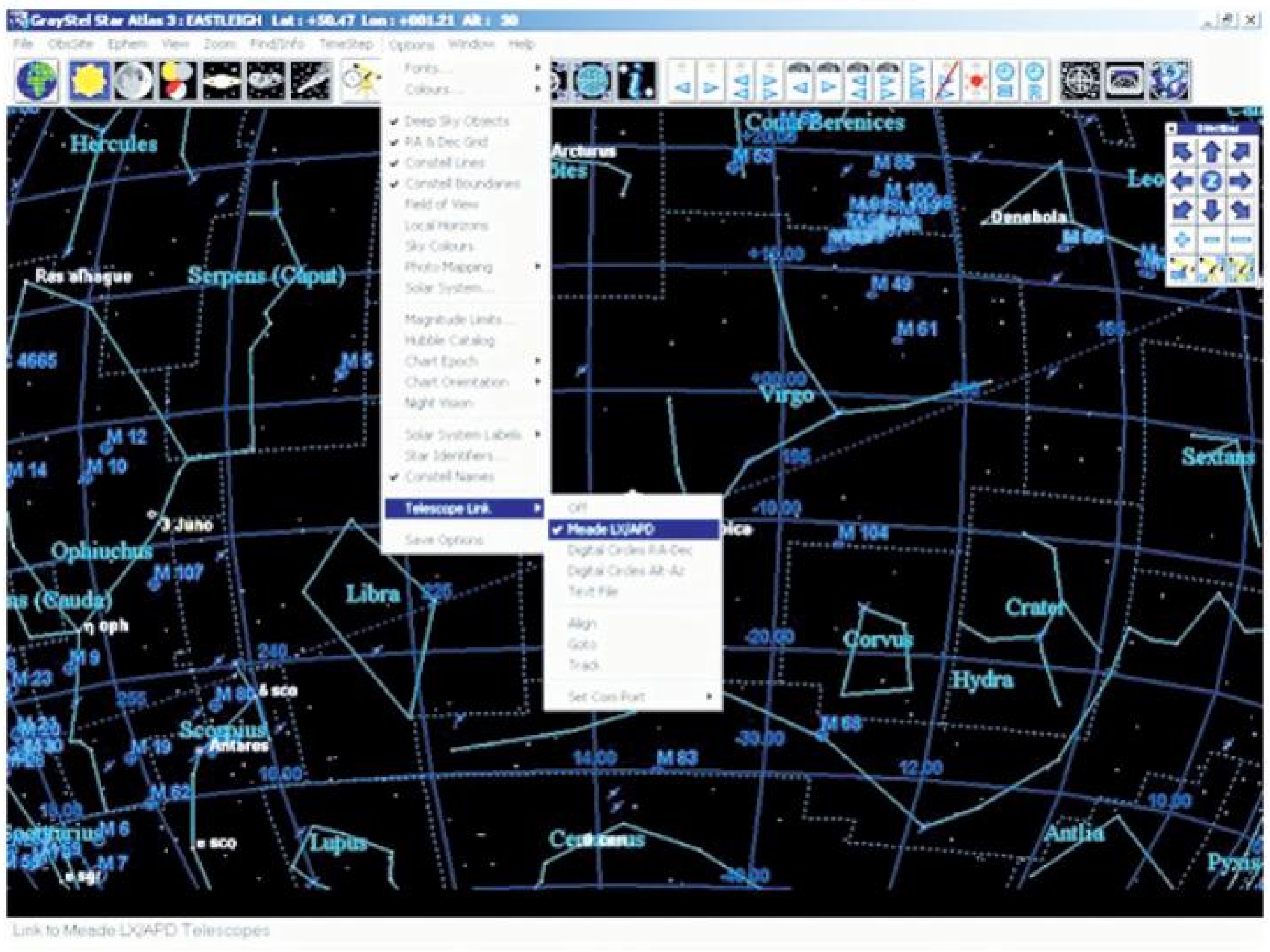

GrayStel Star Atlas 3 : EASTLEIGH Lat : +50.47 Lon : +001.21 AR : 30
File
ObsSite
Ephem
View
Zoom
Find/Info
TimeStep
Options
Window
Help
Fonts...
Colours...
Deep Sky Objects
RA & Dec Grid
Constell Lines
Constell Boundaries
Field of View
Local Horizons
Sky Colours
Photo Mapping
Solar System...
Magnitude Limits...
Hubble Catalog
Chart Epoch
Chart Orientation
Night Vision
Solar System Labels
Star Identifiers...
Constell Names
Telescope Link
Save Options
Off
Meade LX/APD
Digital Circles RA-Dec
Digital Circles Alt-Az
Text File
Align
Goto
Track
Set Com Port
Hercules
Serpens (Caput)
Ophiuchus
Libra
Scorpius
Antares
Lupus
Centaurus
Arcturus
Coma Berenices
Denebola
Virgo
Sextans
Crater
Corvus
Hydra
Antlia
Pyxis
Link to Meade LX/APD Telescopes

Fig.9. Author's Graystel Star Atlas link to Meade LX range of telescopes

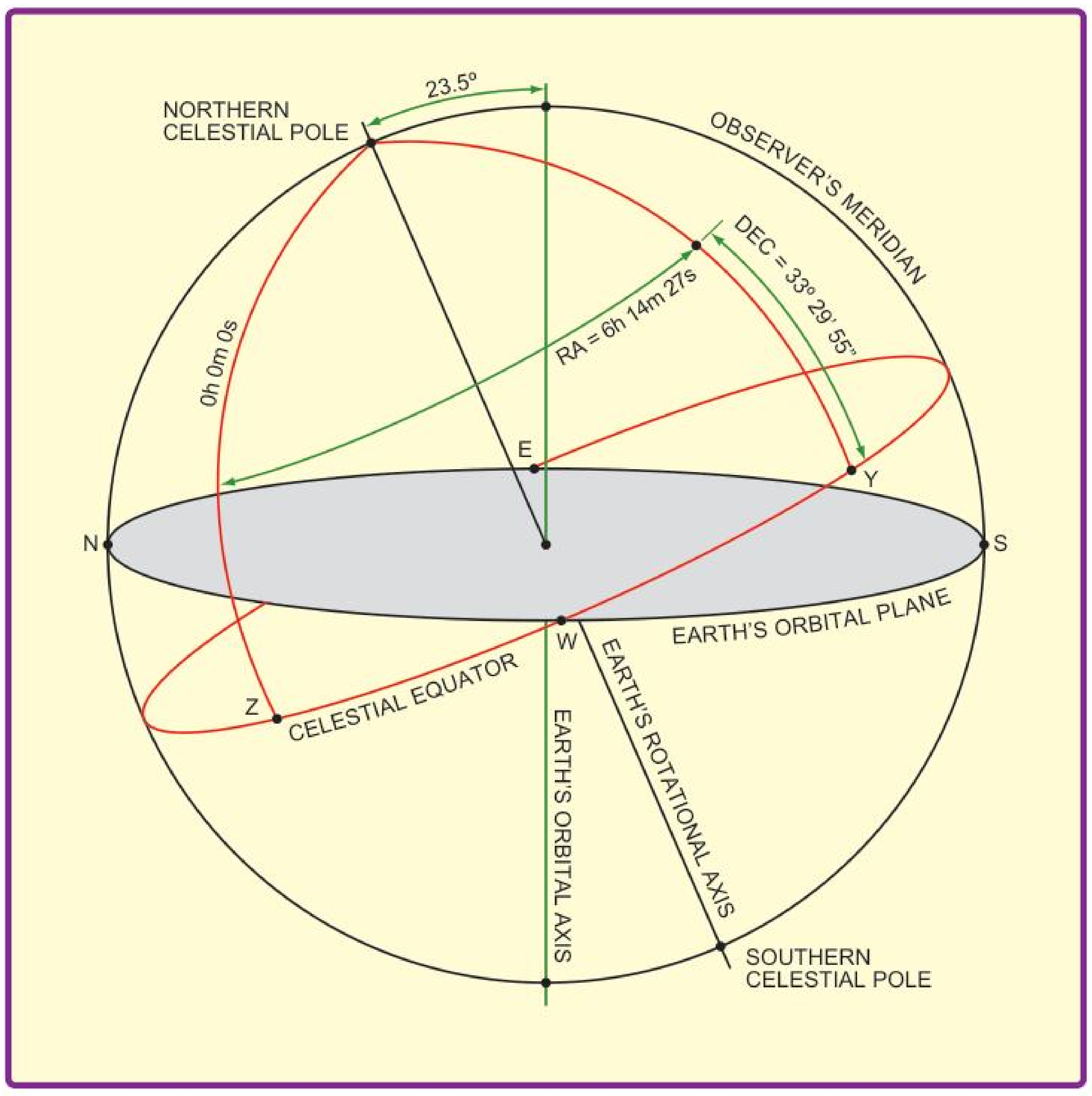

NORTHERN CELESTIAL POLE
23.5°
OBSERVER'S MERIDIAN
DEC = 33° 29' 55"
RA = 6h 14m 27s
0h 0m 0s
E
Y
N
S
W
EARTH'S ORBITAL PLANE
Z
CELESTIAL EQUATOR
EARTH'S ORBITAL AXIS
EARTH'S ROTATIONAL AXIS
SOUTHERN CELESTIAL POLE

Fig.10. Celestial coordinate 'globe'

Precision

The accuracy of my proposed system involves many items including mechanical tolerances, telescope alignment, star chart precision and encoder resolution. Additionally, there are astronomical variants, including precession and nutation (which affect the earth's axis of rotation) and atmospheric refraction (consequentially causing celestial objects to appear in slightly different positions than expected, much as a rowing oar appears to 'bend' where it enters the water). Due to these variations and other perturbations, star charts are updated every 50 years. Our current published charts are for epoch (moment in time) year 2000.

My encoders have 600 steps/rev. As per Fig.11, I receive 4×600 = 2400 state changes/rev. Full coordinate precision for DEC (declination) requires 360 deg × 60 minutes × 60 seconds = 1,296,000 increments, while RA (right ascension) requires 24 hours × 60 minutes × 60 seconds = 86,400 increments.

Some very large numbers, but typically DEC is just given in degrees and minutes, so 360 ×60 = 21,600 increments. RA is given in hours, minutes and tenths of minutes, so 24 × 60 × 10 = 14,400 increments. Therefore, I will need to gear up the encoders ×9 for DEC and ×6 for RA, although this multiplier could be reduced for the DEC based upon the fact that you will never need to go above 90 degrees or below the horizon.

Gearing up encoders is not something I relish, so perhaps more thought is called for? The Graystel and the Meade protocol 'combination' dictate that I use the lower precision option.

The Meade command set includes many instructions, but the most useful and relevant to the Graystel application I am using are:

From the Meade protocol:-

is the command termination character.

:GD# equals "Get telescope declination" and returns sDD*MM#. s = +ve or –ve.

:GR# equals "Get telescope RA" and returns HH:MM.T#. T = tenths of a degree.

:SdsDD*MM# equals "Set target object declination to..." and returns 1(dec accepted) or 0 (dec invalid).

:SrHH:MM.T# equals "Set target RA to ..." and returns 1(valid) or 0 (invalid)

:MS# equals "Slew to target object" and returns 0 (Slew is possible), 1<string># (object below horizon).

:TQ# equals "Select default tracking rate" and returns nothing

To discover exactly what output Graystel produced, I simply looped the Com Port used by Graystel back into a different Com Port and read the result in Hyperterminal. Graystel offers two particularly relevant options; *Track* and *Goto*. In Tracking mode there is a continuous output of #:GR# :GD##:GR# :GD##:GR# :GD##:GR# etc. At any time you may click on the chart followed by a Goto command and the coordinates represented by the mouse click will be sent to the Com Port, eg #:Sr 13:24.6# :Sd +54*56# :MS# :TQ#

Now knowing the output format, code can be written to instruct the PIC. Remember that the '#' command is the termination character, so this can be used to return to the beginning of the routine. A '#' is always followed by a ':' but this could be followed by either a 'G', 'S', 'M' or 'T'. A 'G' can only be followed by an 'R' or a 'D'. An 'S' can only be followed by an 'r' or a 'd'. Therefore, the code can branch accordingly.

The branching code for a PIC 16F877 (PIC and USART setup as per previous examples) is given in Listing 9.

The star chart application can then 'interrogate' the telescope to read it's position by continually sending the following sequence #:GR# :GD##:GR# :GD# etc. #:GR means "get RA" and expects a return of HH:MM.T#:, GD means "get DEC" and expects a return of +/-DD*MM#. Upon receiving valid data, crosshairs appear on the screen and track movement of the telescope redrawing the chart as necessary. So in this mode the star chart displayed on your PC screen functions as a viewfinder. See Fig.12.

Sending data from PIC to PC

To send data from the PIC to the PC simply involves moving the byte to be sent into the working register and then calling the USART transmitting routine. This can be found in Listing 10.

Summary and conclusions

Microchip fans can use the MPASM assembler if desired. Any code written for BSPWA will also compile in MPASM, but obviously only BSPWA is capable of writing the embedded 'Easy USB' code to the PIC.

BSPWA can also load hex files produced by other applications. BSPWA also includes

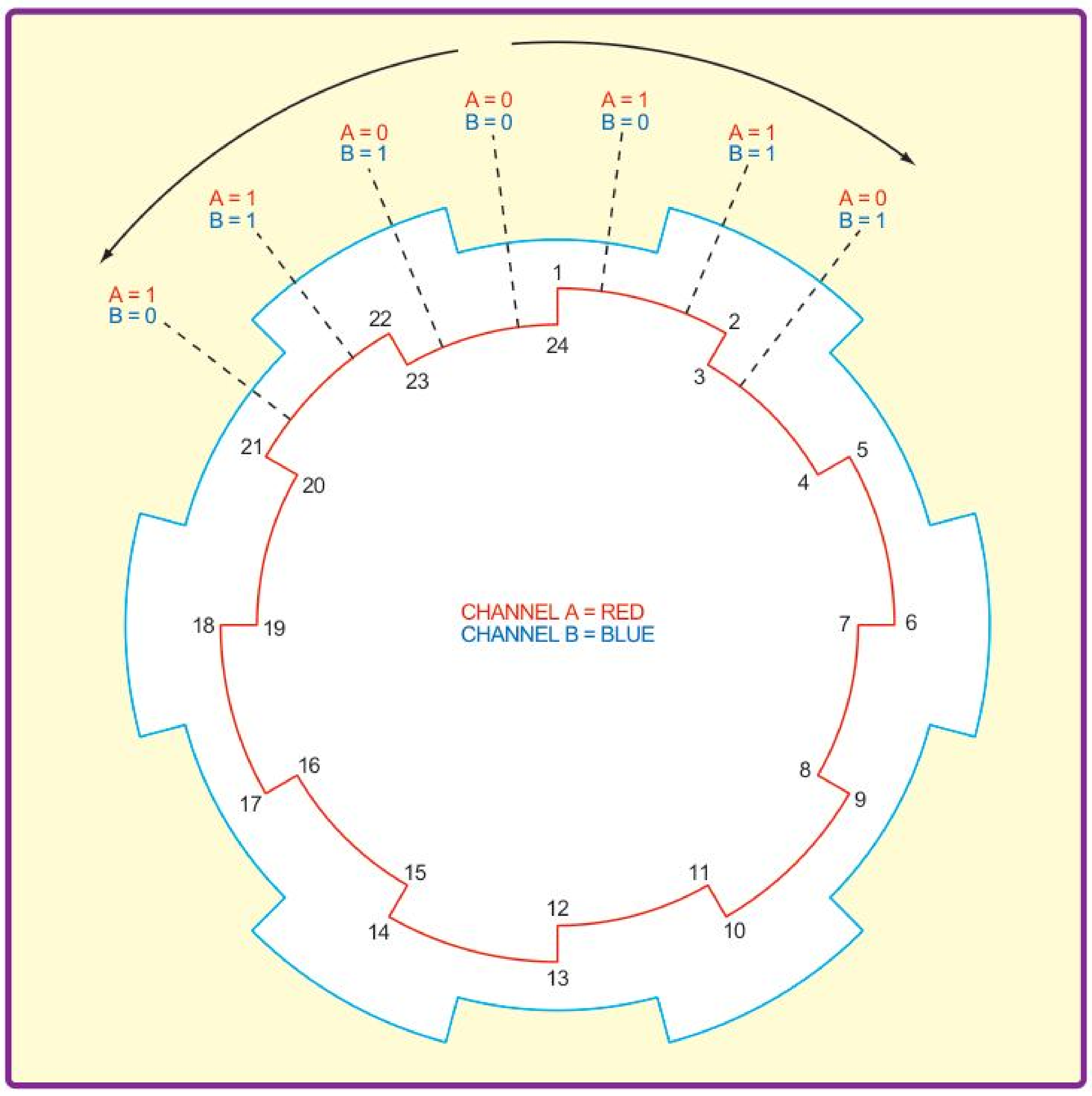
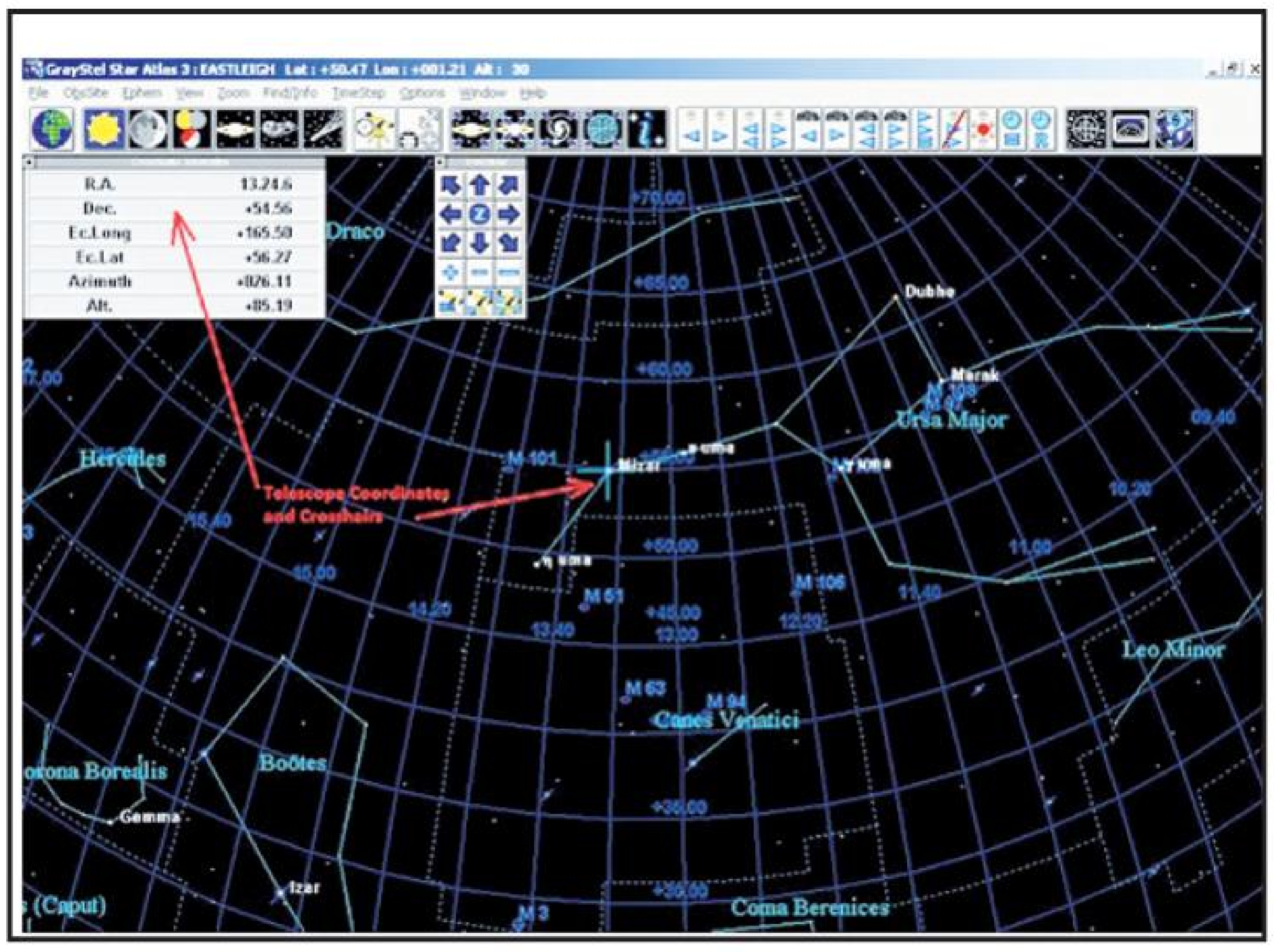

A = 0
B = 0
A = 1
B = 0
A = 0
B = 1
A = 1
B = 1
A = 1
B = 1
A = 0
B = 1
A = 1
B = 0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
CHANNEL A = RED
CHANNEL B = BLUE

Fig.11. Stepping sequence wheel representing a six-pulse dual-channel encoder

useful collections of selectable libraries for delays, reading keypads, writing to LCDs and setting up the USART. In addition, find, replace and compare functions complement the text editor.


GrayStel Star Atlas 3 : EASTLEIGH Lat : +50.47 Lon : +001.21 Alt : 30

R.A.	13.24.6
Dec.	+54.56
Ec.Long	+165.50
Ec.Lat	+56.27
Azimuth	+026.11
Alt.	+85.19

File ObjSite Ephem View Zoom Find/Info TimeStep Options Window Help
Draco
Dubhe
Merak
Ursa Major
Hercules
Telescope Coordinates and Crosshairs
M 101
Mizar
M 106
M 51
Leo Minor
M 63
M 94
Canes Venatici
Corona Borealis
Boötes
Gemma
Izar
(Caput)
M 3
Coma Berenices
+70.00
+65.00
+60.00
+55.00
+50.00
+45.00
+40.00
+35.00
+30.00

Fig.12. Screen star chart functioning as a viewfinder

Graystel is rather an old application and I've not yet been able to run it correctly on anything higher than Windows 2000, but then does this really matter? For the time being, its main advantage for me is that it holds no requirement to 'know' that a telescope is actually connected. There are more up-to-date, fuller featured applications, some of which are free, but I've discovered most supporting the Meade protocol require some form of handshake between PC and scope, or they interface via third party drivers.

Graystel makes no such demands, so for proving the principle it will suffice for now. Graystel only offers connectivity via Com ports 1 to 4, but Windows 2000 does support the USB PIC driver supplied by Brunning Software. Consideration must be given to the number of USB ports previously assigned to devices in order that the USB/USART converter is not assigned a Com port greater than 4.

Easy USB is so simple for the end user. If you have ever researched USB interfacing or tried using any third party DLLs, its complexity somewhat deters you. After all, for PIC-based projects you are only really interested in the basic serial aspect of USB. Easy USB simply provides the necessary entry and exit points.

Note how much additional time is added to the write process when the USB library is included (up to memory location 0x11FF) in your code. You will appreciate just how much work Brunning Software put into developing this superb 'behind-the-scenes' product.

Experimentation, investigation and research to date favour my chances of being able to further develop this project, though doubtless I shall encounter many more obstacles.

Software

Space does not permit the inclusion of the software files in this review/article. Therefore, all relevant software code/files referred as 'Listings' will be posted on the website at: **epemag.com** in the free download section.

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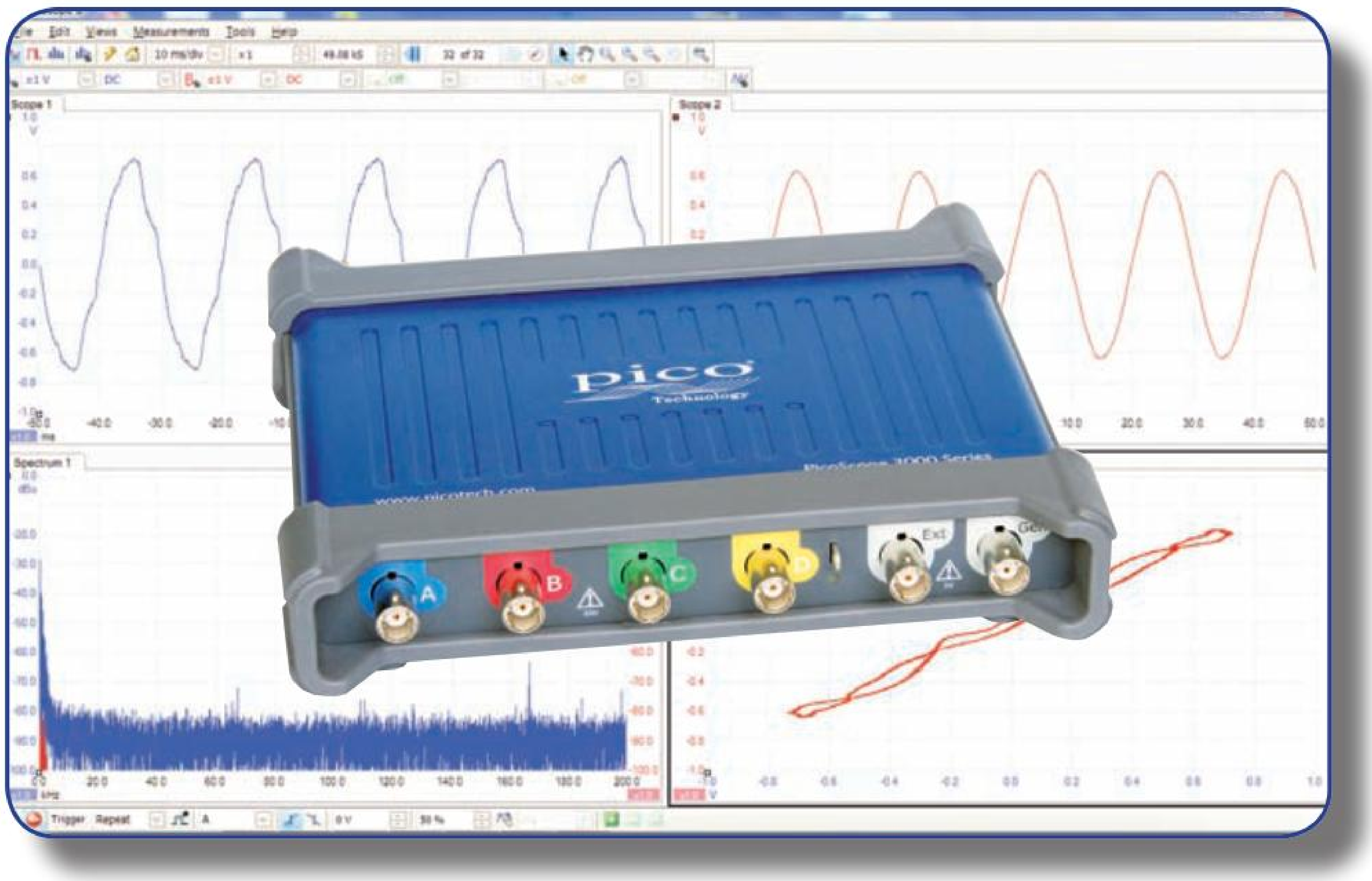
REVIEW . . .

PicoScope 3406B

PC OSCILLOSCOPE

by Robert Penfold

‘Of the various devices I have reviewed over the years, this is the most expensive, but it is also the most impressive.’



NO DOUBT many *EPE* readers will already be familiar with Pico Technology and their interfaces that effectively turn PCs into storage oscilloscopes. The Pico 3406B unit reviewed here is part of their 3000 series, and it is the most advanced unit in this range.

The 3000 series have two or four-channel capabilities, with a sampling rate of 1GS/s (1000 million samples per second) and 8-bit resolution. Depending on the model concerned, the bandwidth is 60, 100, or 200MHz. The amount of storage varies from four million samples in the base unit to 128 million samples at the top of the range.

All 3000 series interfaces have a built-in function generator, and those with a ‘B’ suffix to the model number also have an arbitrary waveform generator. The 3406B therefore has a bandwidth of 200MHz, enough memory to store 128 million samples, and both function and arbitrary waveform generators.

In the box

The unit is housed in a very tough blue and grey plastic case that is quite compact at about 19cm × 17cm × 3.5cm. There are six BNC connectors on the front panel, which are the inputs for channels A to D, an external trigger input, and the output socket for the waveform generators.

There is also an indicator light that is red if the unit is powered up, but not in contact with the controlling software, and switches off when the unit is inactive but detected by the software. It goes green or flashes green if it is active and in contact with the controlling program.

Just above the indicator light there is a terminal that provides a high quality 1kHz squarewave output that can be used for probe compensation adjustments. The probes supplied with the unit are supplied pre-adjusted and ready for use. Presumably, this signal could also be used as a general-purpose test type. The rear panel has an input socket for a mains adapter, a USB port, and an earthing (ground) terminal.

As listed below, the package contains everything most users will require, although a couple of extra test probes would be needed if the unit was used with all four channels, external triggering, and one of the built-in waveform generators. As usual these days, the only printed manual included is a multi-language *Quick Start Guide* that describes the installation process.

The complete Pico 3406B package

The Pico 3406B comes complete with the following accessories:

- Mains adapter
- Single USB lead
- Twin USB lead
- Software installation guide
- Software and Reference disc
- Four ×1/×10 test probes

The program has the usual built-in Help system of course, and some online help is also available.

Getting connected

The unit connects to the host PC via a standard A-B USB cable of the type used with printers and scanners. The power required for its high-speed circuitry is more than a USB port can provide, so it is powered from an external regulated 5V mains-powered plugpack. This comes complete with various adapters that should enable it to plug into mains outlets just about anywhere in the world.

Alternatively, it can be powered from the host PC using a twin USB cable so that power can be obtained from two USB ports. This method will only work with USB ports that can provide a full quota of power. The ports on non-powered hubs and some portable PCs will not suffice. For the purposes of this review I used a mains adapter as the power source, which past experience with this type of thing suggests is likely to be a more reliable method.

I used a PC running Windows 7 for this review, but the supplied software is compatible with Windows XP and Vista as well. The hardware requirements are not particularly demanding, and practically any PC that runs under one of the supported versions of Windows should be adequate. However, a large and fairly high resolution display is needed in order to make the most of the accompanying PicoScope 6 software.

On connecting the unit to the PC it was recognised by Windows and the required driver software was automatically installed. The version of the PicoScope 6 program already installed on the PC did not recognise the 3406B interface, but uninstalling the existing software and reinstalling the Pico 6 software supplied with the 3406B cured this problem. The program installed in standard Windows fashion without any problems.

PicoScope 6

The PicoScope 6 program does not make an attempt at mimicking the control panel and screen of a real oscilloscope, but instead takes a more conventional approach to things. There are menu and toolbars at the top of the screen, and a control bar at the bottom, but the rest of the screen is available for displaying waveforms.

This is perhaps less intuitive to use than software that provides a full-blown virtual oscilloscope with virtual knobs and switches, but it is more practical in that it does leave a large screen area for displaying waveforms. This is important if you need to display (say) four waveforms simultaneously in separate windows (Fig.2). Also, because of its conventional user interface, anyone familiar with Windows software should have little difficulty in learning to use PicoScope 6.

The menus provide access to many of the program's technical features, in addition to standard Windows features such as facilities for saving data in various graphics formats or a CSV spreadsheet, and printing a waveform to any installed printer. The upper toolbar has a drop-down menu that enables the sweep rate to be set at preset steps from 2ns to 1000s per division, and this increments in the standard oscilloscope 1-2-5-10 sequence.

Button up

There is an Auto Setup button and operating this button results in the input signal being analysed. After a short delay, the program provides what it deems to be the optimum settings for sweep rate and sensitivity.

The three buttons on the extreme left of this toolbar determine the type of display that will be provided. The first option provides a conventional oscilloscope waveform display, and the second one sets the display in Persistence mode. In this mode the trace produced by the previous sweep is not deleted before the next trace is added. With a changing waveform this results in a complex display building up. This is rather like the display produced using a conventional oscilloscope equipped with a long persistence tube.

The third button turns the unit into a frequency-based instrument, and it is then primarily a spectrum analyser. Various maximum frequencies from 100Hz to 200MHz are available in this mode via a drop-down menu that replaces the one for setting the sweep rate. A fourth button enables the frequency-based mode to be set up in the required fashion. You can select linear or logarithmic scaling for example.

Panning and zooming

The buttons in the right-hand section of the upper toolbar provide panning and zooming facilities for the display. One of these enables the view to be zoomed in the horizontal plane by a factor of 2, 4, 8, 16, and so on, up to a maximum of 512. This is essentially the same as the X expansion control on a conventional oscilloscope, albeit with rather more expansion available than when using the conventional equivalent. Normal Windows style pan and zoom controls are also available, including the type where you drag a rectangle around part of the display, and then that area is the zoomed to fill the display area.

A thumbnail view of the complete waveform is displayed when a zoomed view is selected, and this shows a rectangle around the zoomed part of the waveform (as in the bottom display of Fig.3). It is possible to pan the display by simply dragging this rectangle using the mouse, and the extents of the display can be changed by dragging the edges of the rectangle.

The lower toolbar is primarily concerned with enabling or disabling each of the four channels, and setting the sensitivity of any channel that is operational. A range of full-scale sensitivities from +50mV to +20V are available via drop-down menus, and these have increments in the usual 1-2-5-10 sequence. On all inputs the maximum safe input potential is 20V, although this can effectively be increased to 200V by using the probes in the ×10 setting.

Pico
Technology
www.picotech.com
PicoScope 3000 Series
A
B
C
D
Ext

Front panel layout for the PicoScope 3406B

There is an Auto option for each channel, and this sets the sensitivity as high as possible without clipping the waveform. Small drop-down menus enable the channels to be individually set for AC or DC operation.

Starting line

The control bar along the bottom of the screen provides various trigger options. There are on and off buttons, plus buttons and menus that provide options such as triggering on the rising or falling edge, auto, repetitive, and single-sweep operation. Any active channel can be used to provide the trigger signal, and external triggering is also available. A range of trigger levels is available.

The timebase can be set in free-running mode with no synchronisation, and there is also an automatic mode where the software selects whichever type of triggering it deems most appropriate for the characteristics of the input signal.

Multiple display windows are supported, and each window can display something different. For example, a conventional dual-trace display can be obtained by having separate display windows for channels

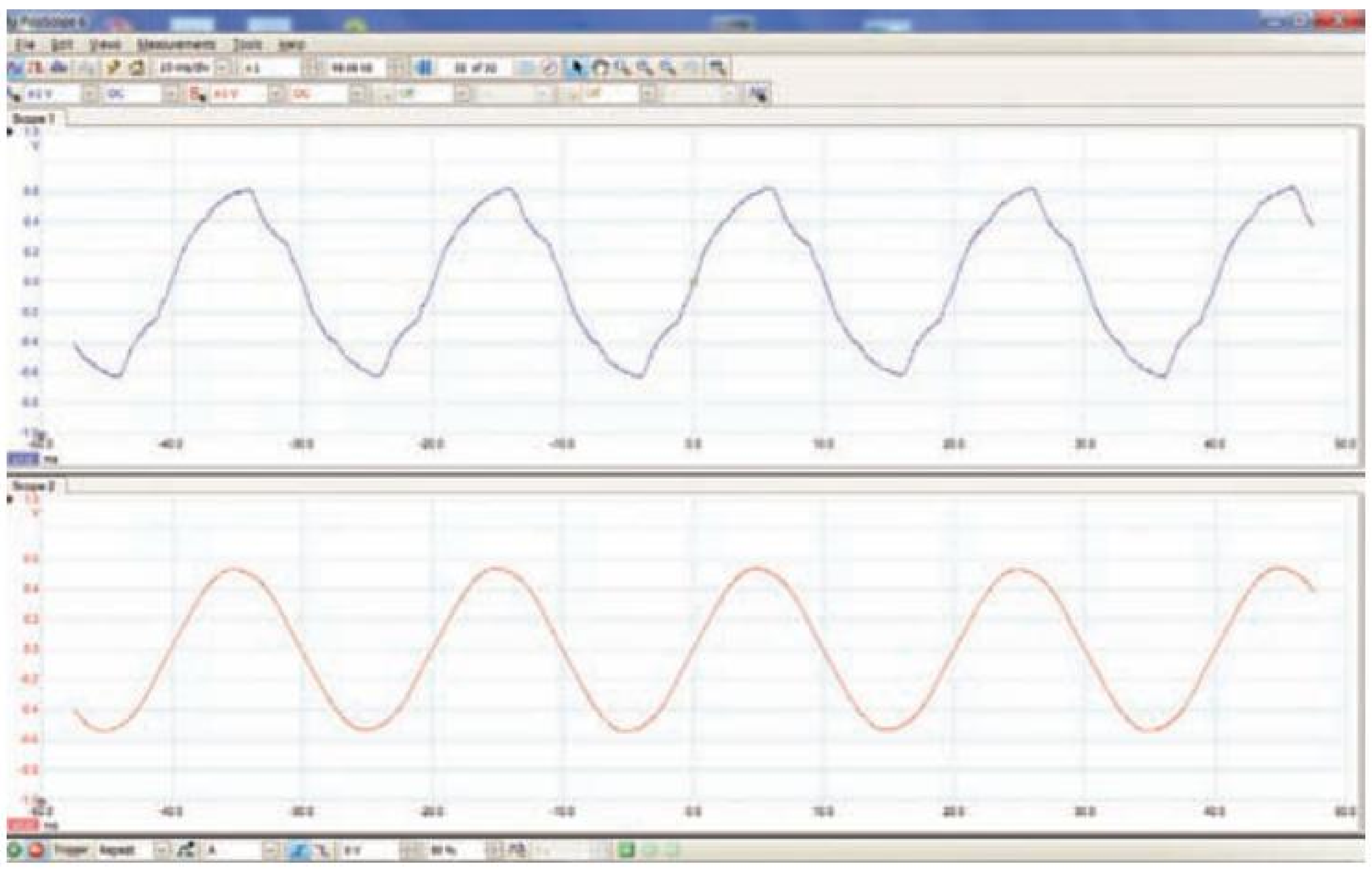


Fig.1. The PicoScope 3406B operating with twin traces in separate windows. The lower trace is produced from the same signal as the upper one, but it has been filtered using the built-in low-pass filtering

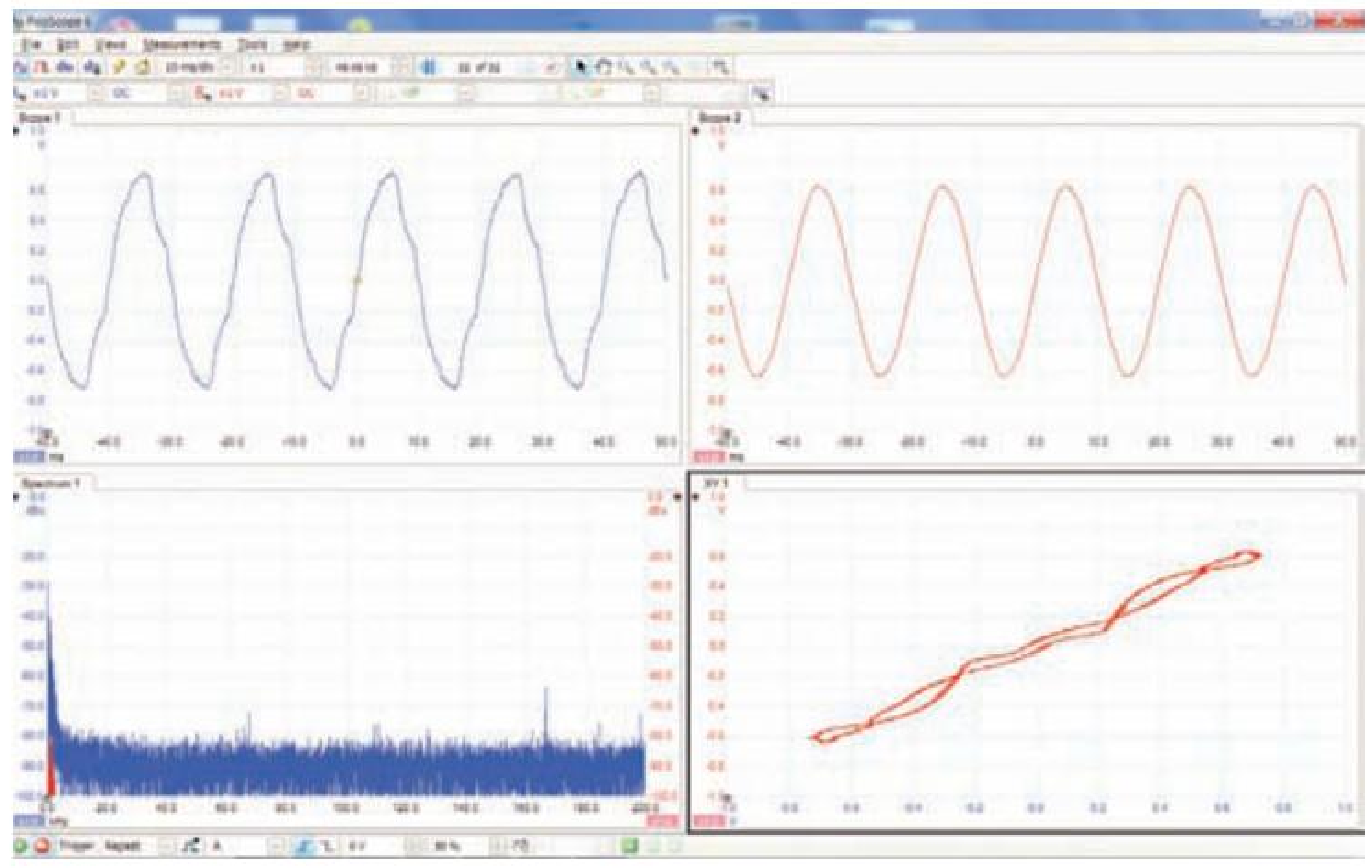


Fig.2. It is possible to have multiple windows with each one showing a different signal, or operating in a different mode. The bottom right-hand window is using the X-Y mode to display a Lissajous figure

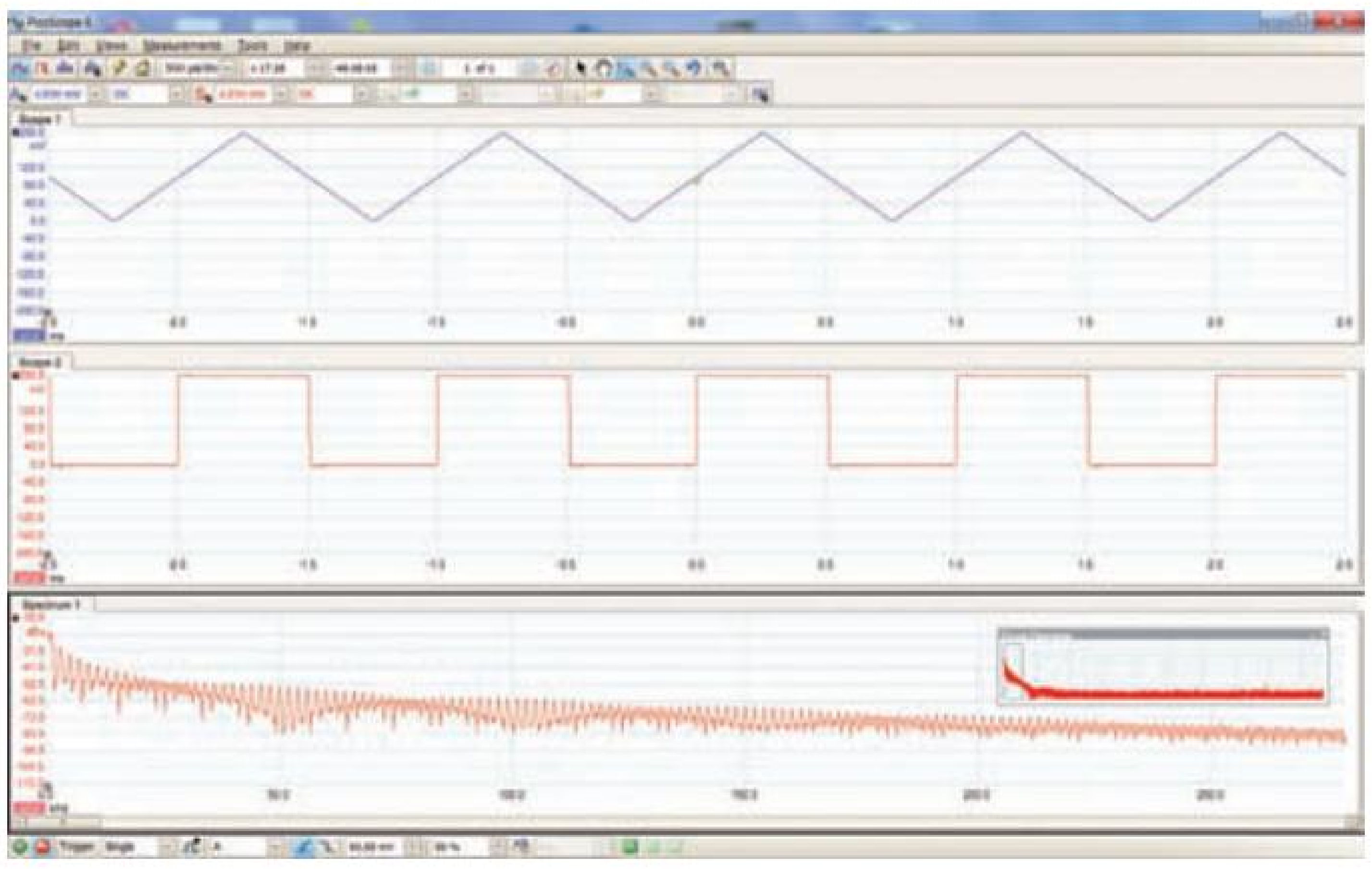
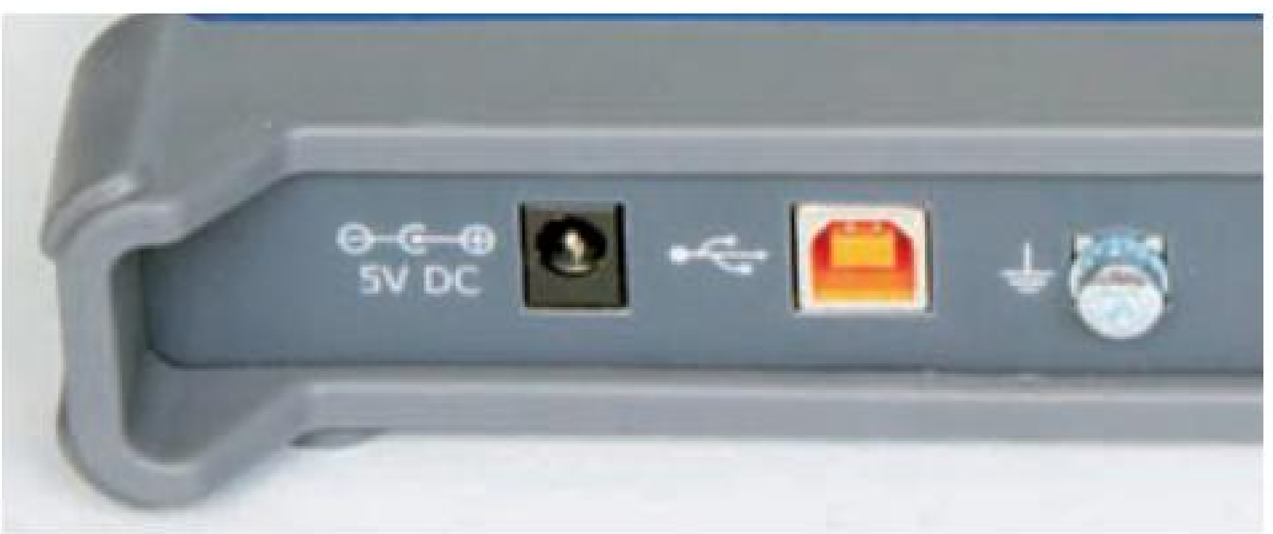


Fig.3. The bottom window is showing a zoomed view. The thumbnail view in this window can be used for panning and altering the level of zooming



Rear panel sockets and ground terminal

A and B, with the channel A window above the one for channel B, as in Fig.1. The two traces can be shown in a single window if preferred.

More elaborate setups can be used if required. It is permissible to have (say) waveform displays in three windows and a spectrum analyser display type in a fourth window, which is the arrangement used in Fig.2. A window that is in Scope Mode can be set for X-Y operation, so that Lissajous figures can be produced (bottom right-hand window in Fig.2).

There is a new feature that enables lowpass filtering to be applied to the displayed signal. The cut-off frequency can be set between 1Hz and 500MHz. Presumably, the filtering is provided by digital signal processing rather than in hardware, and it seems to be very effective.

Of course, with oscilloscopes it is normally maximum bandwidth that is required, so that waveforms are displayed as faithfully as possible. However, it can sometimes be useful to remove high frequency noise from a signal so that the underlying waveform can be seen more clearly. In Fig.1 the upper trace is 50Hz mains 'hum', and the lower trace is the highly 'cleaned' version of the same signal.

Making waves

The button at the right-hand end of the lower toolbar brings up a dialogue box that offers a number of output waveforms including sine, square, triangular, two types of ramp, and white noise. A range of output frequencies from 0.03Hz to 1MHz can be provided. Optionally, the output frequency can be swept up or down.

As one would probably expect, with some waveforms the quality of the output signal reduces somewhat at higher frequencies. However, the quality of the squarewave signal is quite good at 100kHz, and the sinewave quality is excellent even at 1MHz. The output level can be set at various levels from 2V peak-to-peak down to 1mV peak-to-peak.

Opting for the arbitrary waveform generator brings up the new window of Fig.4, where there are various ways of producing the waveform to be synthesised. An input waveform can be copied, a CSV spreadsheet can be used as the source, you can draw the waveform, or a standard waveform can be selected and then modified. In Fig.4, I have used this last method using a sinewave signal as the starting point. It is possible to use the oscilloscope and signal generator functions at the same time, and in Fig.5 the waveform design of Fig.4 has been captured on channel A of the oscilloscope.

There are other useful features to the program, and it is possible to use the maths functions to display such things as channel A plus channel B, channel A minus channel B, or an inverted version of a channel. It is also possible to add various types of measurement bar at the bottom of a window. These can show things such as frequency, RMS voltage, rise-time, and fall-time.

Anyone contemplating the purchase of a Pico unit would be well advised to download the demonstration version of PicoScope 6 and to explore its many possibilities.

Conclusion

The PicoScope 3406B performed as claimed by the manufacturer, and the PicoScope 6 software ran without problems during the test period. They come from a company that has a proven track record in this field, and one would probably not expect anything less than this.

Anyone buying this impressive piece of hardware and excellent software should be well pleased with them, and the PicoScope 3406B can certainly be recommended.

Although it is at the top of the 3000 series, it is an upper mid-range unit in the various ranges of PC oscilloscopes offered by this company. At £1349.00 excluding VAT it is certainly not cheap, but for a unit with such a large buffer and 200MHz bandwidth it is competitively priced.

One of the other PicoScopes would probably be a better choice, unless you really need everything that the 3406B has to offer. For example, the 3404A with its smaller buffer, 60MHz bandwidth, and no arbitrary waveform generator is less than half the price of the 3406B.

If you do need its range of facilities the PicoScope 3406B will not disappoint. Of the various electronic devices I have reviewed over the years it is the most expensive, but it is also the most impressive.

For more information contact Pico Technology Ltd, James House, 3 Marlborough Road, Colmworth Business Park, Eaton Socon, St Neots, Cambridgeshire, PE19 8YP, Tel: 01480 396395, Fax: 01480 396296, Email: **sales@picotech.com**. More information and demonstration software is available from the Pico web sites at: **www.picotech.com**

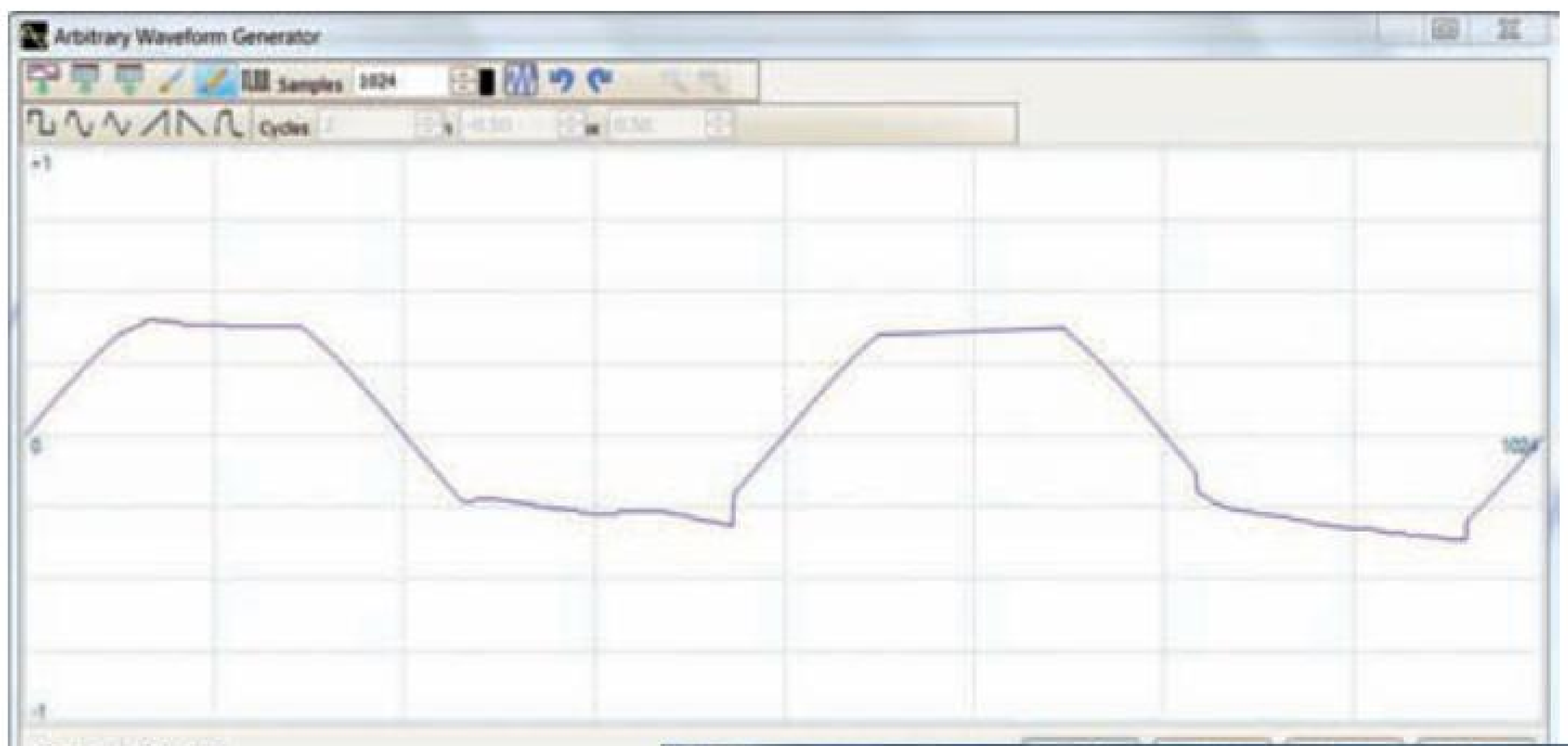


Fig.4 (left). Using the waveform generator it is possible to produce any desired waveform. In this example a sinewave signal was used as the starting point, and some clipping was added

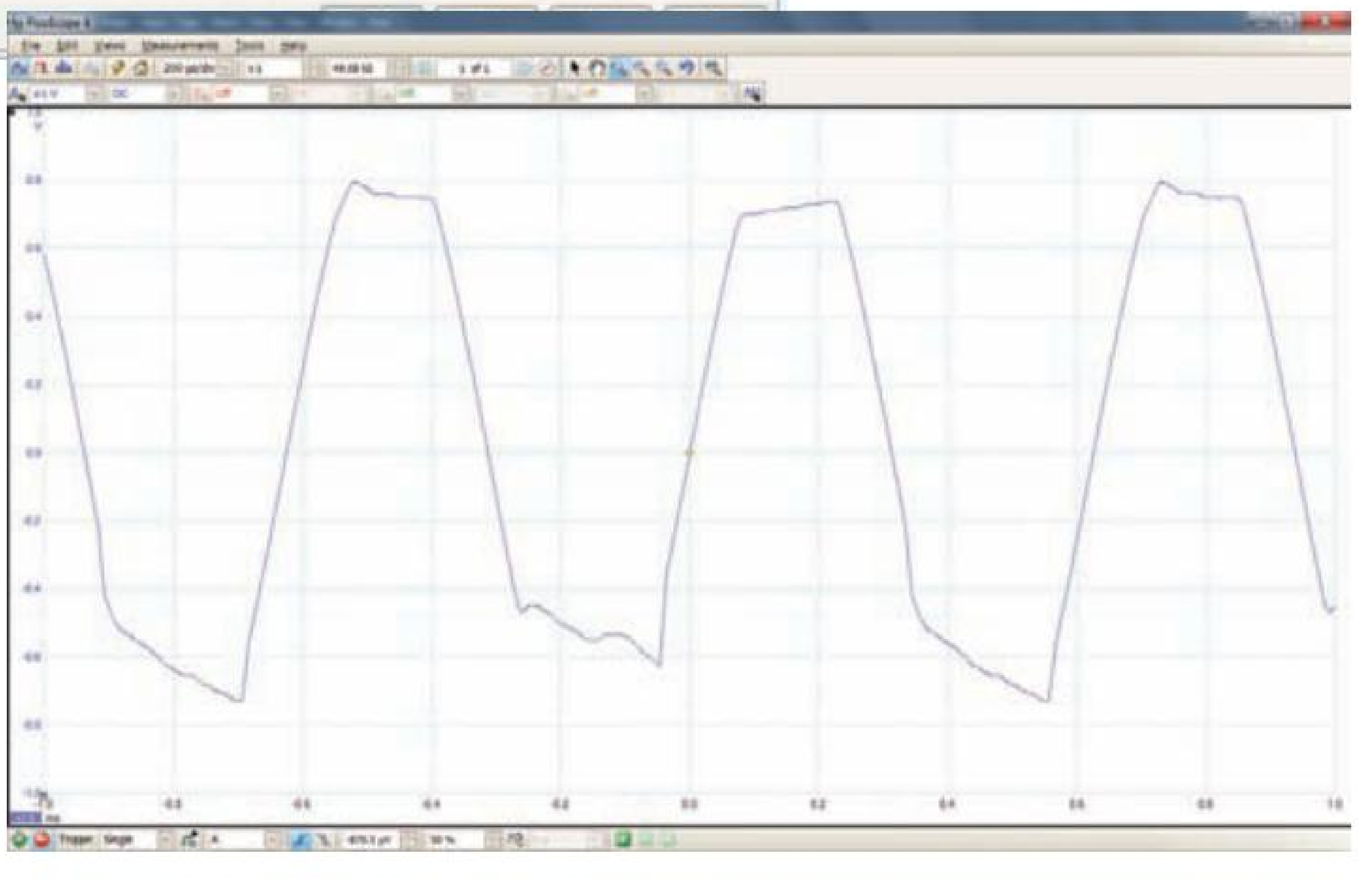
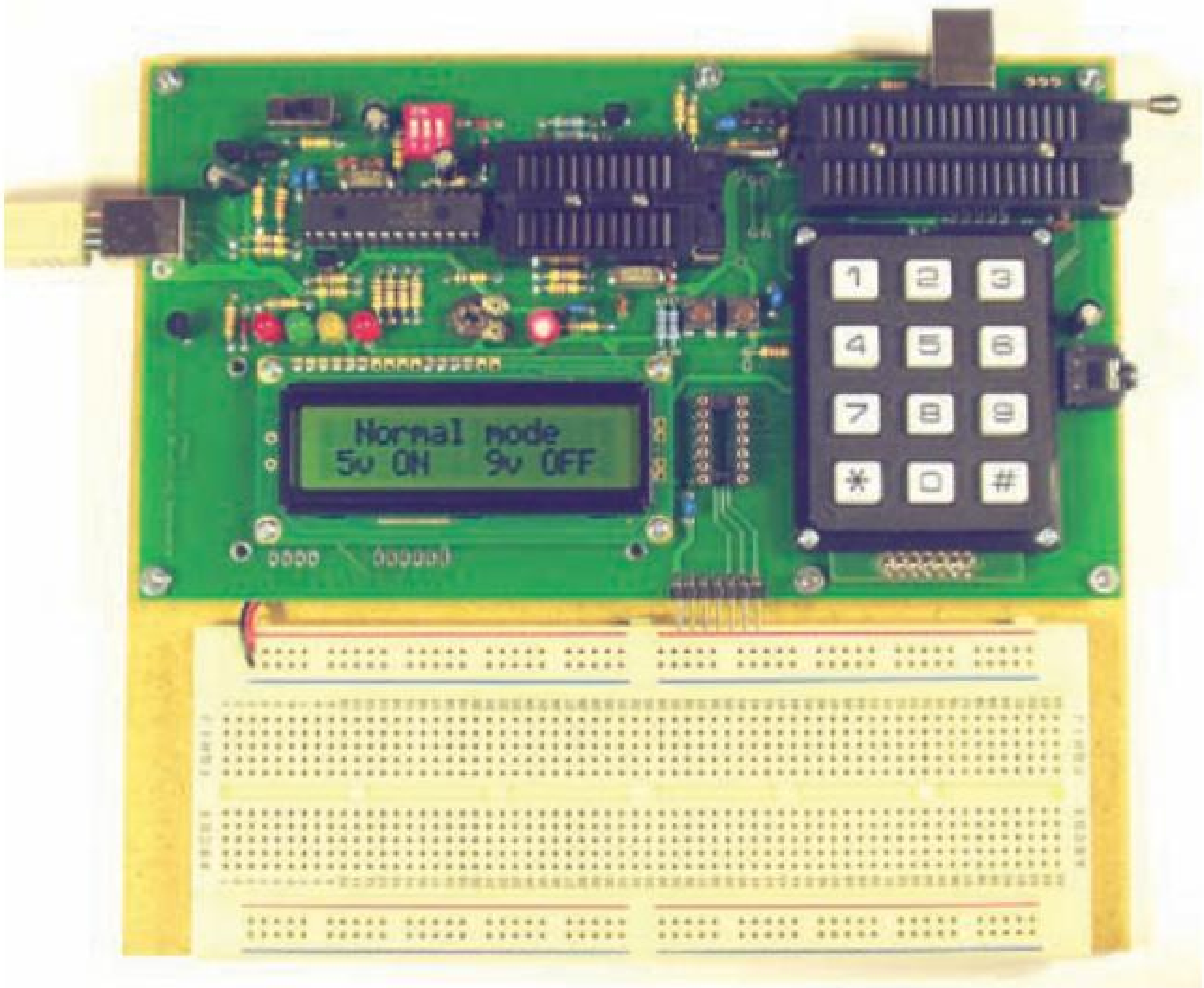


Fig.5 (right). It is possible to use the built-in waveform generator and the oscilloscope section simultaneously. Here the scope is being used to show the output signal from the waveform generator, which is producing the waveform design of Fig.4

PIC Training Course



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Experimenting with PIC C

The second book starts with an easy to understand explanation of how to write simple PIC programmes in C. Then we begin with four easy experiments to learn about loops. We use the 8/16 bit timers, write text and variables to the LCD, use the keypad, produce a siren sound, a freezer thaw warning device, measure temperatures, drive white LEDs, control motors, switch mains voltages, and experiment with serial communication.

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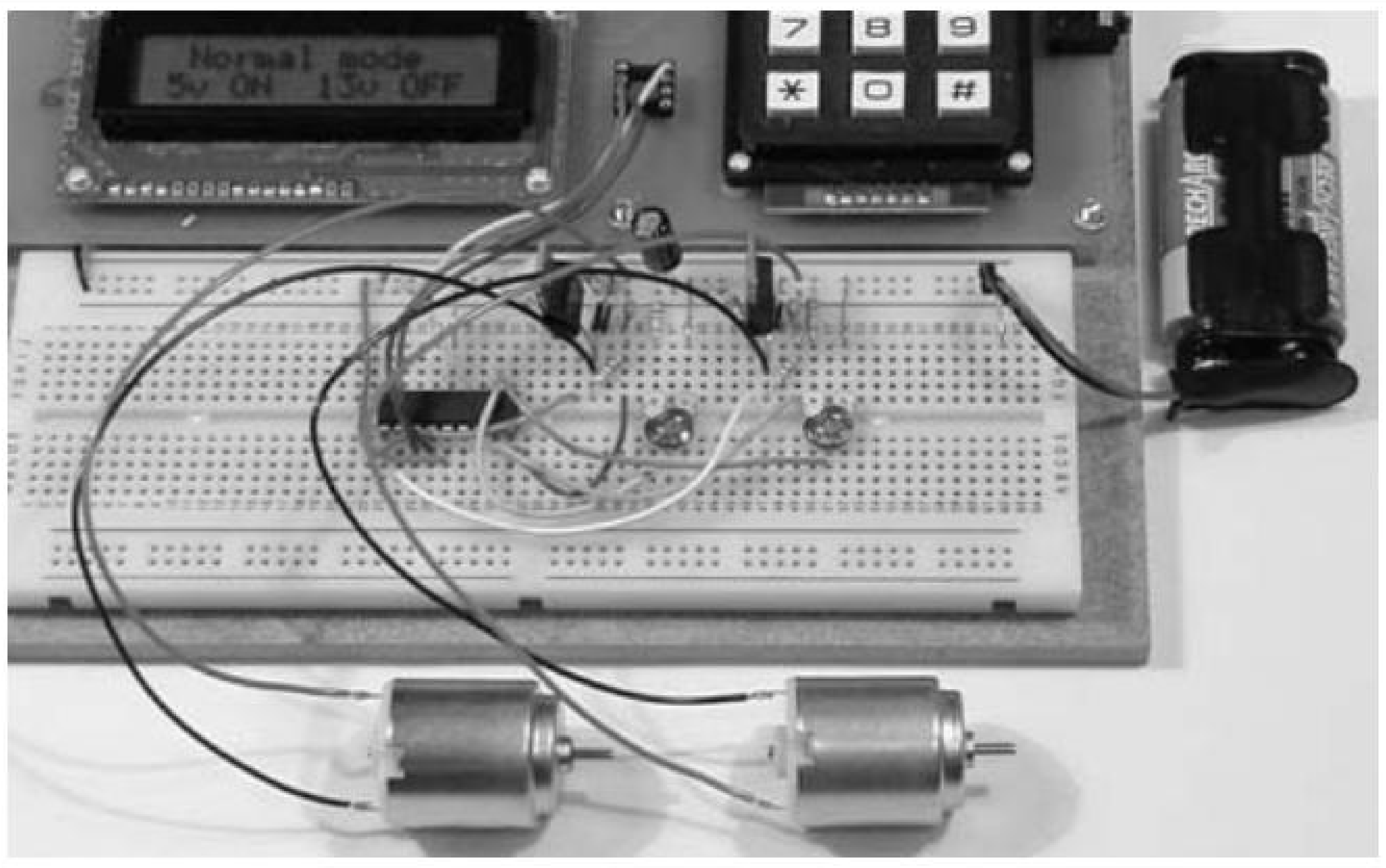

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Jump Start

By Mike and Richard Tooley

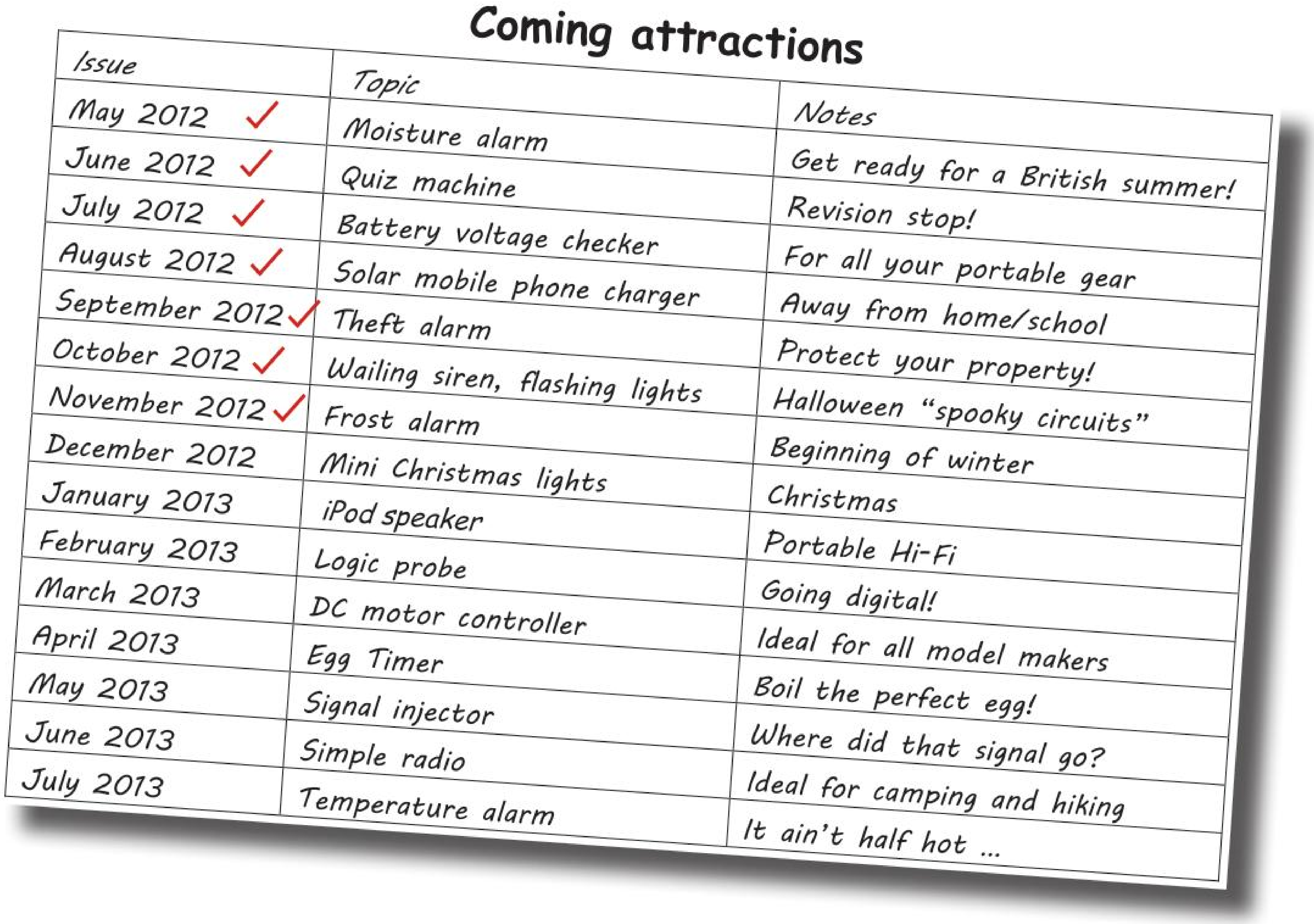
Design and build circuit projects dedicated to newcomers, or those following courses taught in schools and colleges.

WELCOME to *Jump Start* – our new series of seasonal 'design and build' projects for newcomers. *Jump Start* is designed to provide you with a practical introduction to the design and realisation of a variety of simple, but useful, electronic circuits. The series will have a seasonal flavour, and is based on simple, easy-build projects that will appeal to newcomers to electronics, as well as those following formal courses taught in schools and colleges.

Each part uses the popular and powerful 'Circuit Wizard' software package as a design, simulation and printed circuit board layout tool. For a full introduction to Circuit Wizard, readers should look at our previous *Teach-In series*, which is now available in book form from Wimborne Publishing (see *Direct Book Service* pages 75-77 in this issue).

Each of our Jump Start *circuits include the following features:*

- ***Under the hood*** **–** provides a little gentle theory to support the general principle/theory behind the circuit involved
- ***Design notes*** **–** has a brief explanation of the circuit, how it works and reasons for the choice of components
- ***Circuit Wizard*** **–** used for circuit diagrams and other artwork. To maximise compatibility, we have provided two different versions of the Circuit Wizard files; one for the education version and one for the standard version (as supplied by *EPE*). In addition, some parts will have additional files for download (for example, templates for laser cutting)
- ***Get real*** **–** introduces you to some interesting and often quirky snippets of information that might just help you avoid some pitfalls
- ***Take it further*** **–** provides you with suggestions for building the circuit and manufacturing a prototype. As well as basic construction information, we will provide you with ideas for realising your design and making it into a complete project
- ***Photo Gallery*** **–** shows how we developed and built each of the projects.



Coming attractions

Issue	Topic	Notes
May 2012 ✓	Moisture alarm	Get ready for a British summer!
June 2012 ✓	Quiz machine	Revision stop!
July 2012 ✓	Battery voltage checker	For all your portable gear
August 2012 ✓	Solar mobile phone charger	Away from home/school
September 2012 ✓	Theft alarm	Protect your property!
October 2012 ✓	Wailing siren, flashing lights	Halloween "spooky circuits"
November 2012 ✓	Frost alarm	Beginning of winter
December 2012	Mini Christmas lights	Christmas
January 2013	iPod speaker	Portable Hi-Fi
February 2013	Logic probe	Going digital!
March 2013	DC motor controller	Ideal for all model makers
April 2013	Egg Timer	Boil the perfect egg!
May 2013	Signal injector	Where did that signal go?
June 2013	Simple radio	Ideal for camping and hiking
July 2013	Temperature alarm	It ain't half hot ...

Frost alarm

In this month's Jump Start *we shall be getting ready for the winter months with a device that will provide you with a useful warning of the imminent danger of frost and ice. This handy project is invaluable for motorists and gardeners, and could be instrumental in avoiding some of the dangers associated with freezing temperatures.*

Under the hood

The Frost Alarm uses several of the circuit techniques that we have introduced previously in *Jump Start*, notably the use of an operational amplifier (op amp) as a comparator and the use of a 555 timer as an astable oscillator to generate an audible alarm signal.

The simplified block schematic of our *Frost Alarm* is shown in Fig.1. The temperature sensing device is a small thermistor. Unlike conventional resistors, which maintain a reasonably constant resistance over a wide range of temperature, the resistance of a

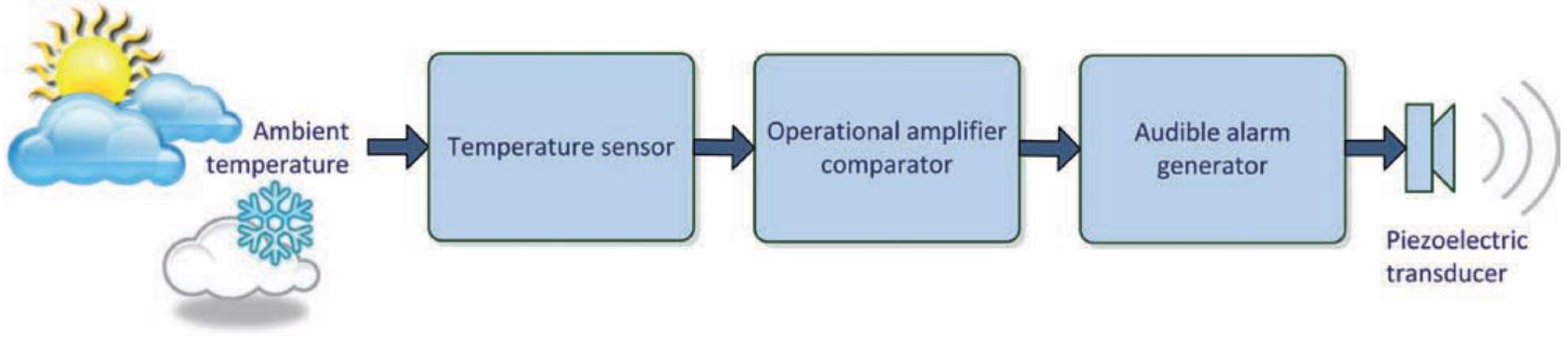


Fig.1. Simplified block schematic of our Frost Alarm

thermistor is intended to change considerably with temperature.

Thermistors are widely employed in temperature sensing and temperature compensating applications. Two basic forms of thermistor are available according to whether their temperature coefficient of resistance is negative (NTC) or positive (PTC).

Typical negative temperature coefficient (NTC) thermistors have resistances that vary from a few thousand ohms at 25°C to a few hundreds of ohms at 100°C, as shown in Fig.2(a). Positive temperature coefficient (PTC) thermistors, on the other hand, usually have a resistance-temperature characteristic that remains substantially flat (typically at around 100Ω) over the range 0°C to 75°C. Above this, and at a critical temperature (usually in the range 80°C to 100°C), the resistance of a PTC thermistor rises rapidly to values up to and beyond 10kΩ, as shown Fig.2(b).

Because of its more linear resistance-temperature characteristic, we will be using a low-cost NTC thermistor as our sensing device in the Frost Alarm. Such components are available at reasonable cost and they can be easily mounted in a small space. The component that we have chosen for use in the Frost Alarm has the temperature characteristic shown in Fig.3.

Wheatstone bridge

The next problem that we need to solve is how to convert the change in resistance produced by our thermistor sensor into a voltage that we can use to trigger an alarm. To do this, we have chosen a simple Wheatstone bridge arrangement in conjunction with an operational amplifier comparator (see July 2012 *EPE*, page 49). The thermistor sensor will form one 'arm' of a Wheatstone bridge, as shown in Fig.4(c).

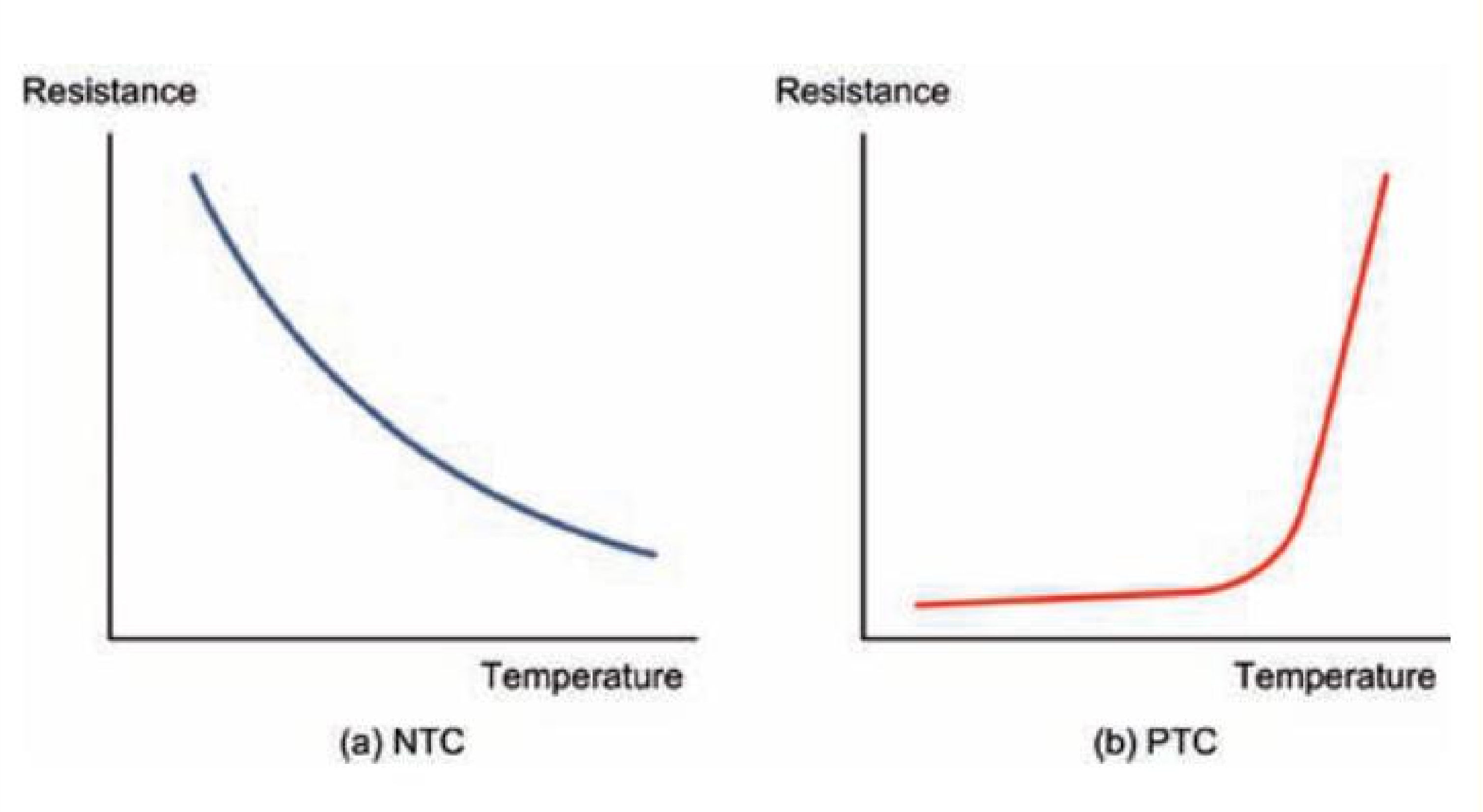


Fig.2. Resistance-temperature characteristic for (a) an NTC thermistor and (b) a PTC thermistor

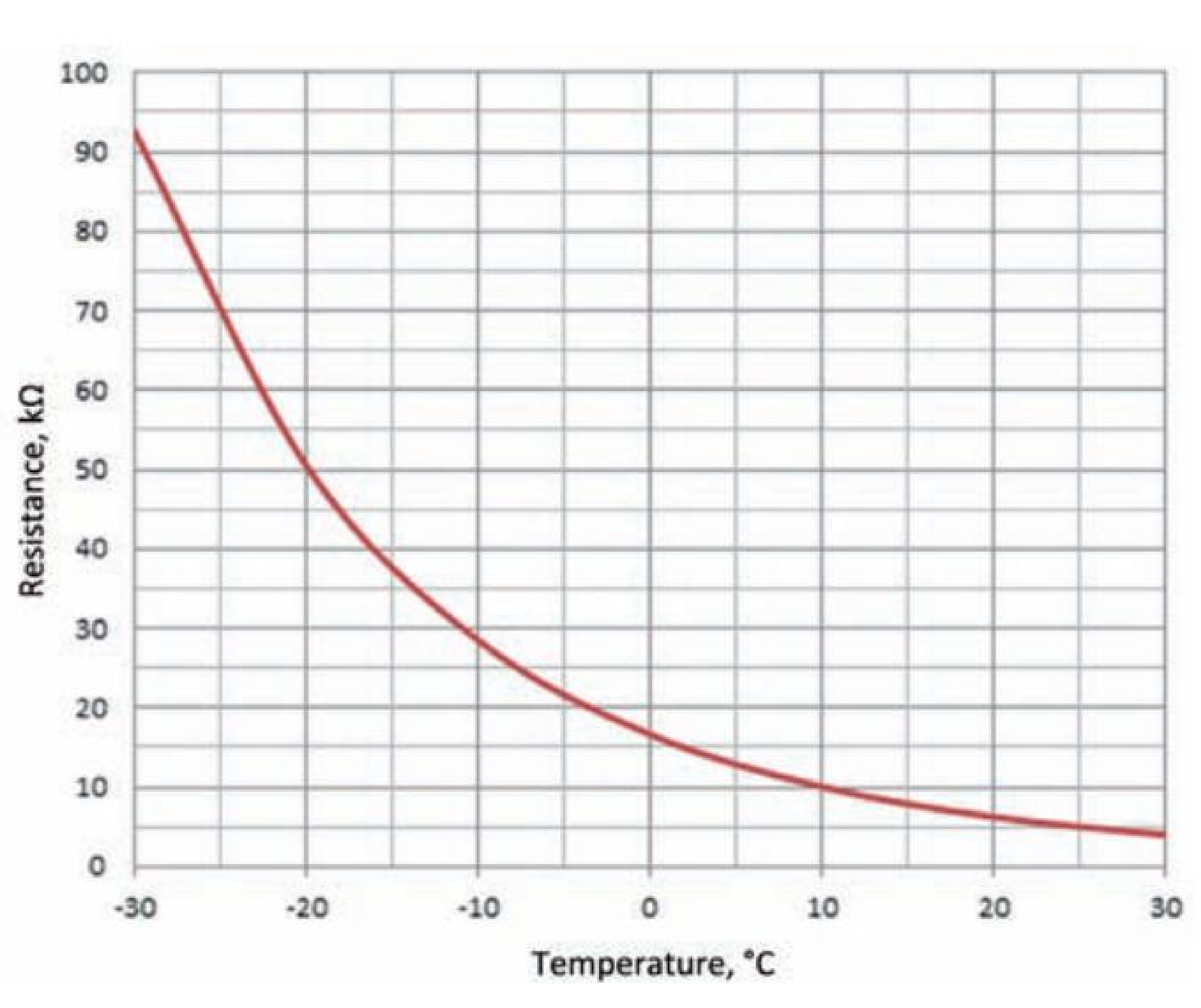


Fig.3. Resistance-temperature characteristic for the NTC thermistor used in the Frost Alarm

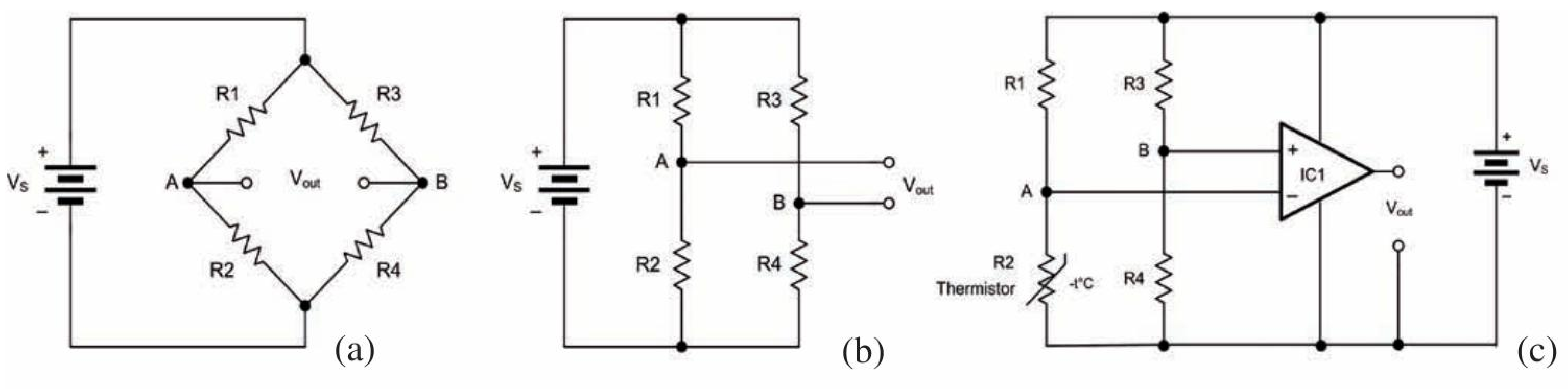


Fig.4. Wheatstone bridge arrangement (with a thermistor forming one arm of the bridge). (a) Basic Wheatstone bridge configuration; (b) Bridge drawn as two potential dividers and (c) Temperature sensing arrangement

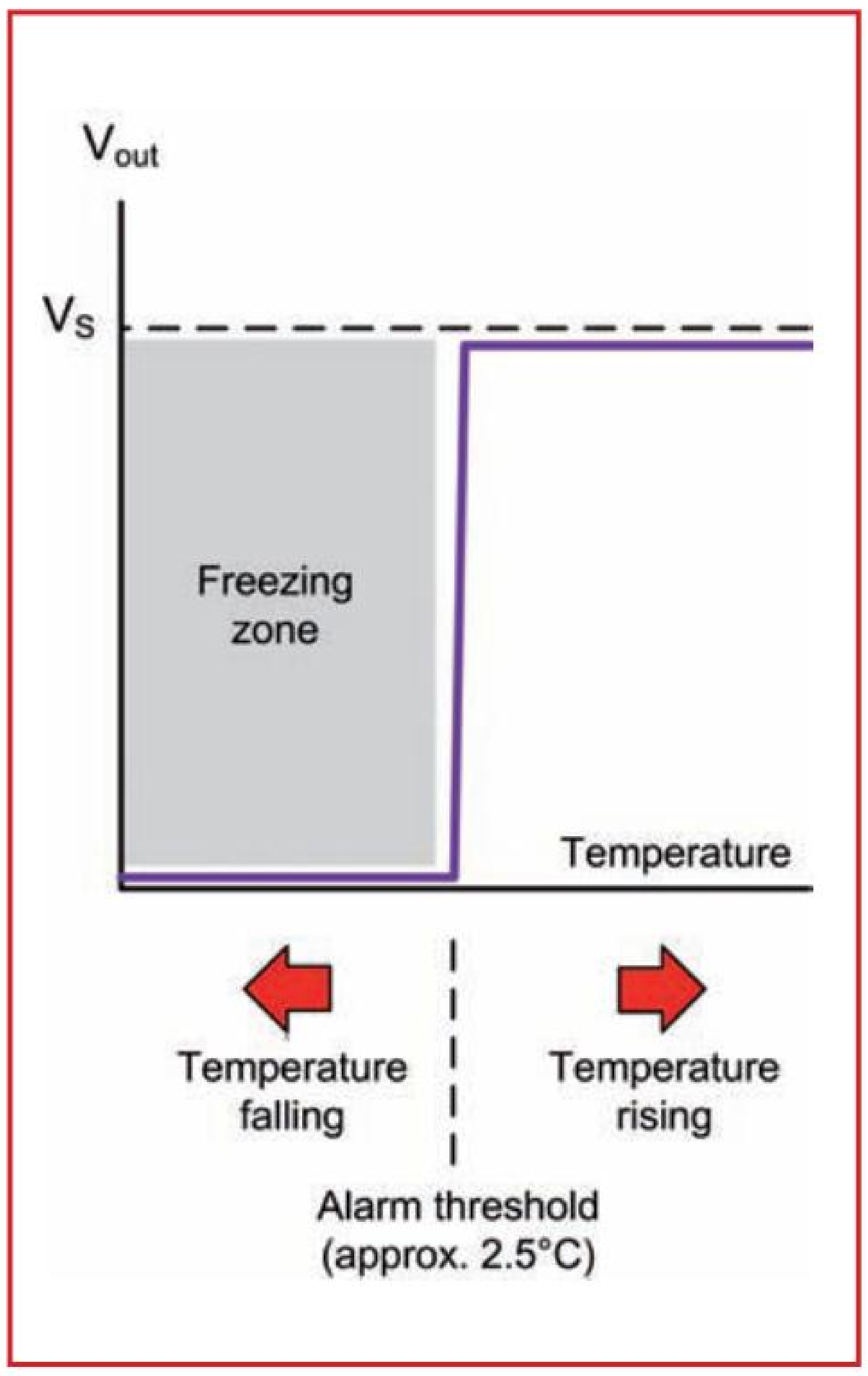


Fig.5. Output voltage from the operational amplifier comparator stage

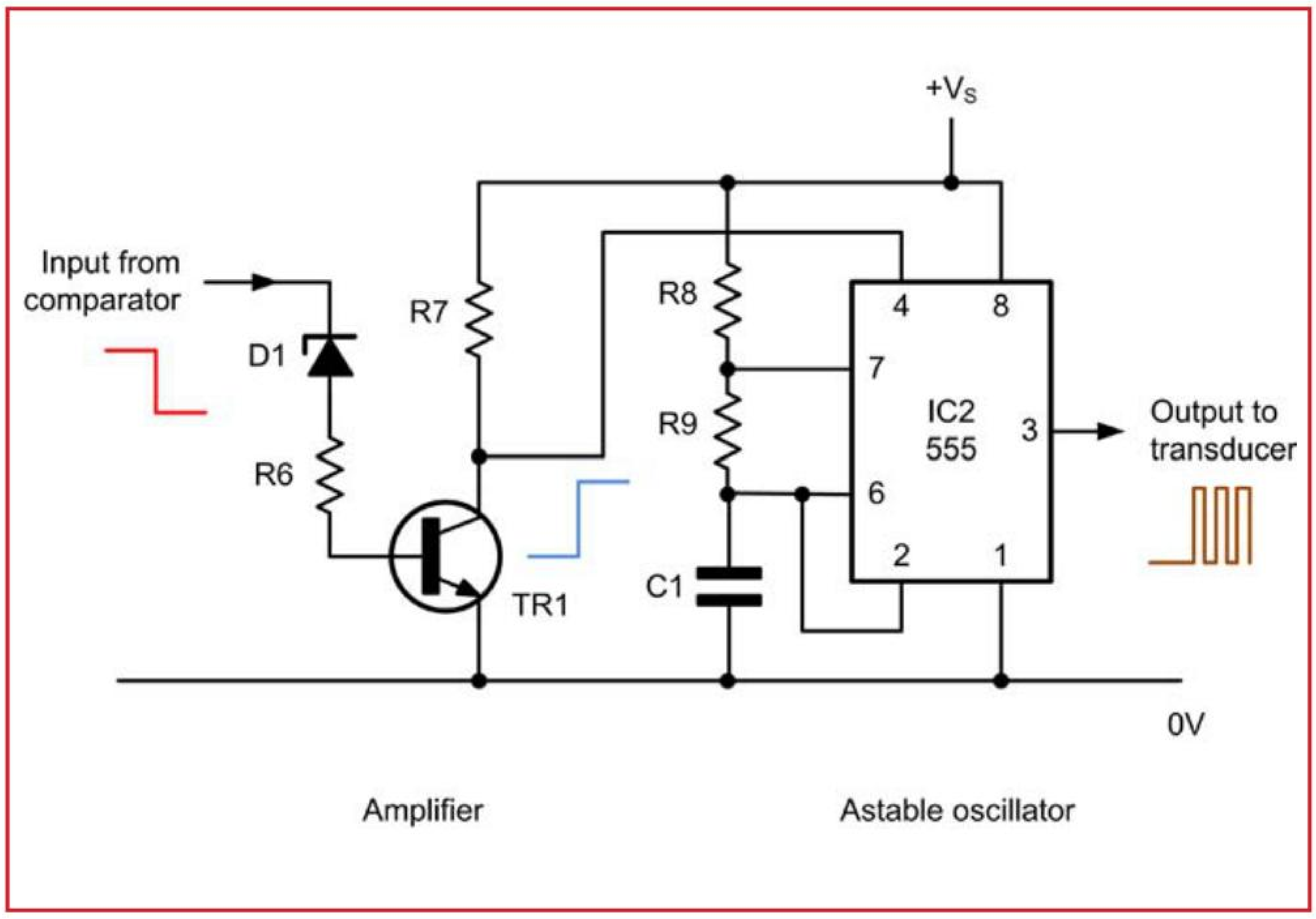


Fig.6. Amplifier and 555 astable oscillator stage

The Wheatstone bridge forms the basis of a number of electronic circuits, including many that are used for instrumentation and measurement. In the basic form of the Wheatstone bridge shown in Fig.4(a), the voltage developed between A and B will be zero when the voltage developed between A and Y is the same as the voltage developed between B and Y. In this condition, the bridge is said to be 'balanced'.

The two sets of adjacent resistors, R1 and R2 and R3 and R4, each constitute a potential divider, as shown in Fig.4(b). When the bridge is in the balanced condition, the voltage dropped across R2 will be the same as that which appears across R4. Similarly, in this condition the voltage dropped across R1 will be identical to that dropped across R3.

From this we can conclude that, for balance (and hence zero voltage between A and B) to occur, the ratio of R1 to R2 must be the same as the ratio of R3 to R4. This leads to the bridge equation:

R1/R2 = R3/R4

From which R2 = R1 × (R4/R3)

Note that in our Frost Alarm circuit R2 is the resistance of the thermistor sensing element.

Design notes

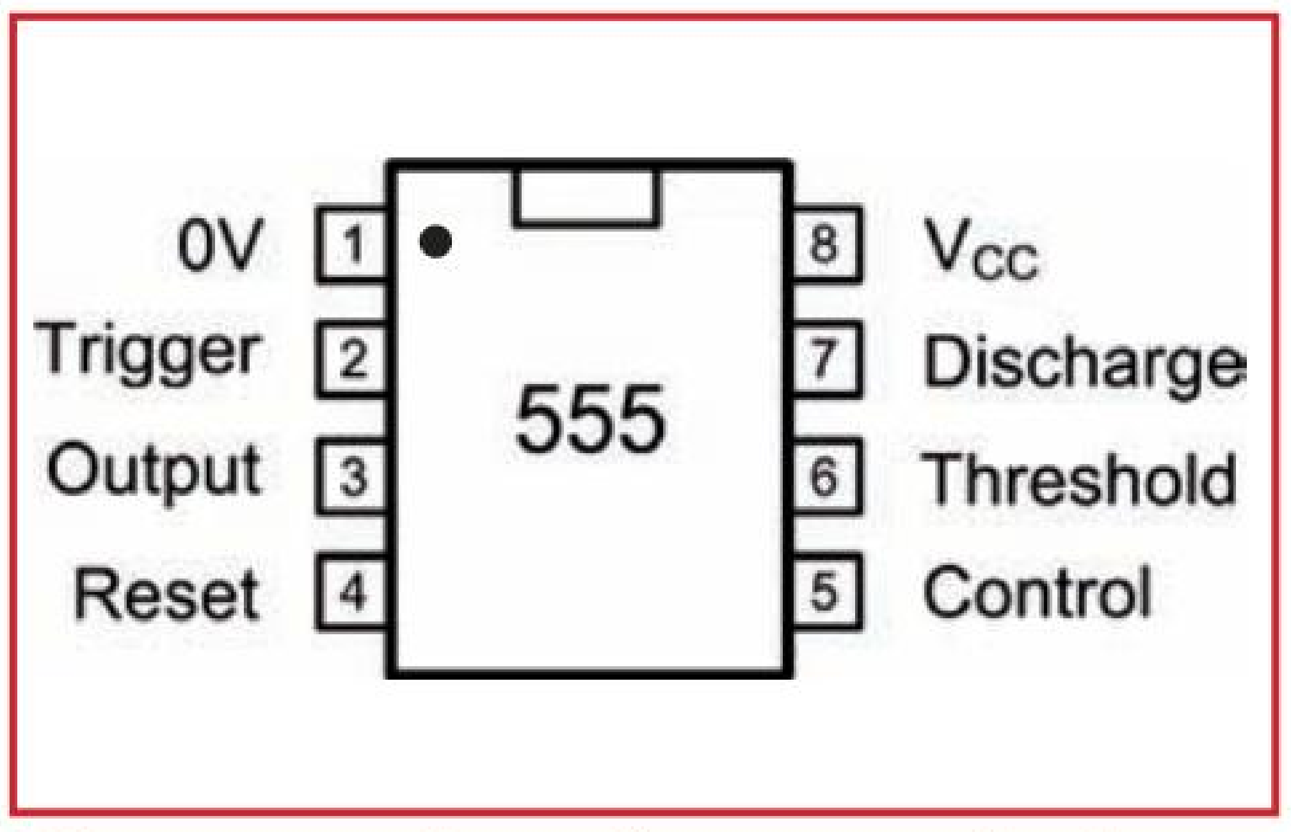
Our Frost Alarm is to be designed so that it produces an alarm signal whenever the ambient temperature falls below a critical value (typically around 3°C). So, rather than a linear output of voltage we need to produce a voltage that will change rapidly from one level to another whenever the resistance of an NTC thermistor falls below a pre-determined value.

The output voltage from the bridge is fed to an operational amplifier that acts as a comparator, as shown in Fig.4(c). The operational amplifier has an extremely high value of voltage gain, so only a small change in input voltage is required to produce a very large change in voltage at the output.

In practice, and assuming that all four resistors have approximately the same value, the output voltage of the operational amplifier will swing between two extremes; either 0V when the thermistor's resistance, R2, is greater than R4, or just less than the supply voltage when the thermistor's resistance is smaller than R4. Fig.5 shows how the output voltage of IC1 falls very rapidly when the ambient temperature falls below the threshold value (typically this will be set at a value just above freezing).

The output from the comparator can be used to control a simple 555 astable oscillator. However, in practice, we will require some additional amplification and shaping due to the inability of a real operational amplifier to produce an output voltage that changes over the full supply range.

Note that the output of a comparator stage based on a real operational amplifier neither falls to precisely zero nor does it rise to the full supply voltage. To overcome this problem we have introduced an additional amplifier stage, as shown in Fig.6.



Pin connections for a standard 555 timer IC

The output of the amplifier formed by transistor TR1 and associated components is applied to the Reset input (pin 4) of the 555 astable

A note regarding Circuit Wizard versions:

Circuit Wizard is available in several variants; Standard, Professional and Education (available to educational institutions only). Please note that the component library, virtual instruments and features available do differ for each variant, as do the licensing limitations. Therefore, you should check which is relevant to you before purchase. During the Jump Start series we aim to use circuits/features of the software that are compatible with the latest versions of all variants of the software. However, we cannot guarantee that all items will be operational with every variant/version.

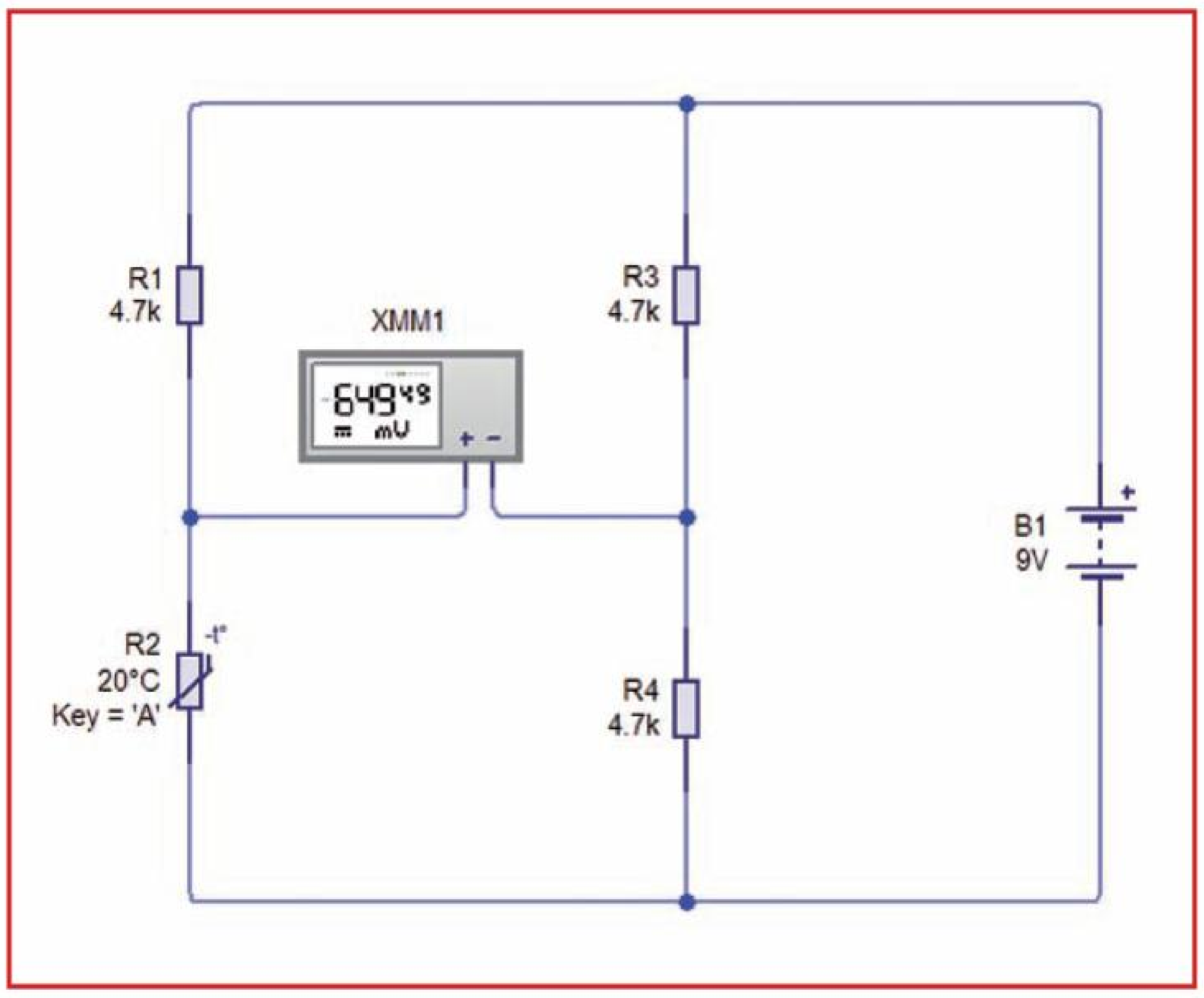
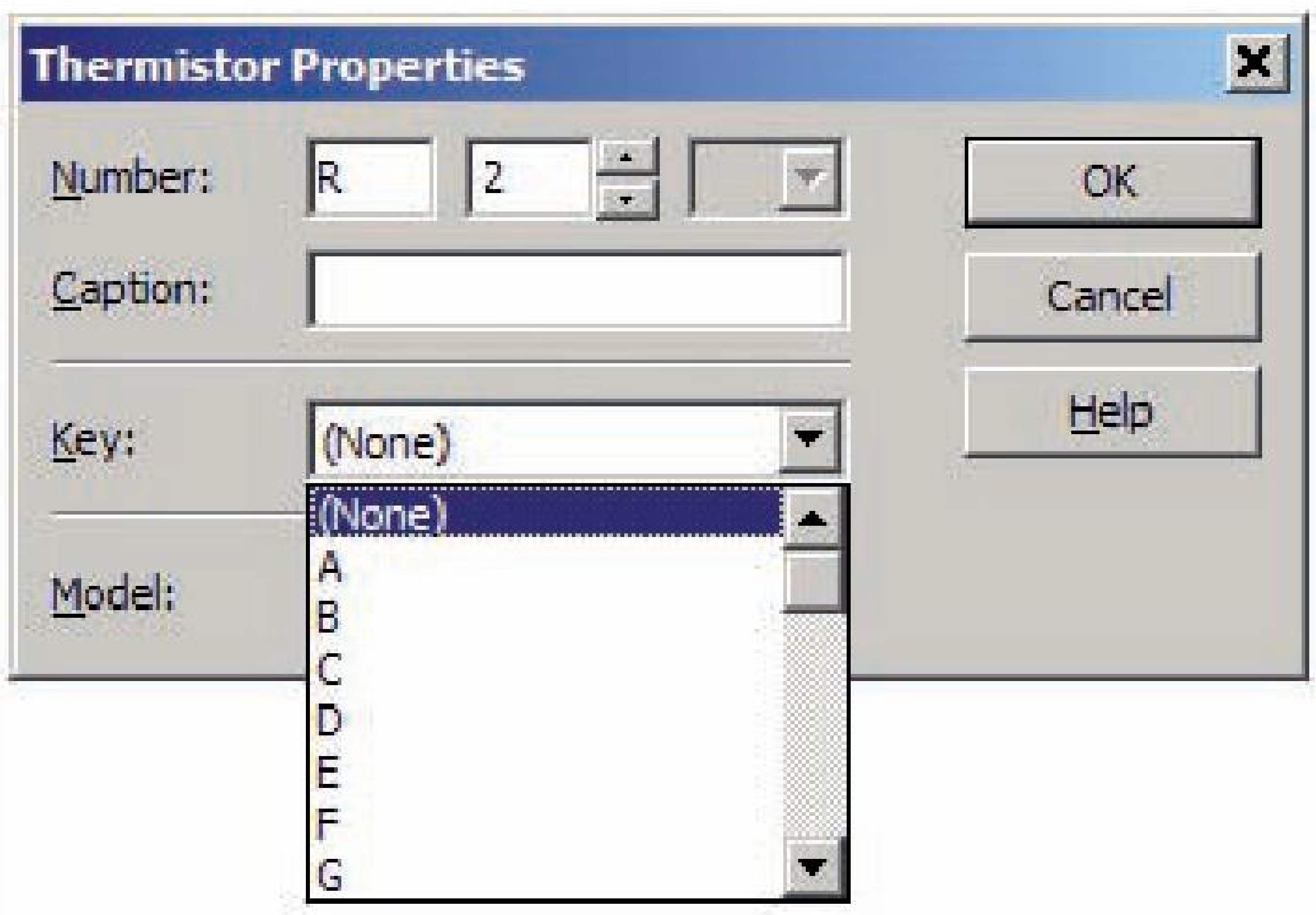


Fig.7. Using Circuit Wizard to test the temperature sensing bridge



Thermistor Properties

Number: R 2

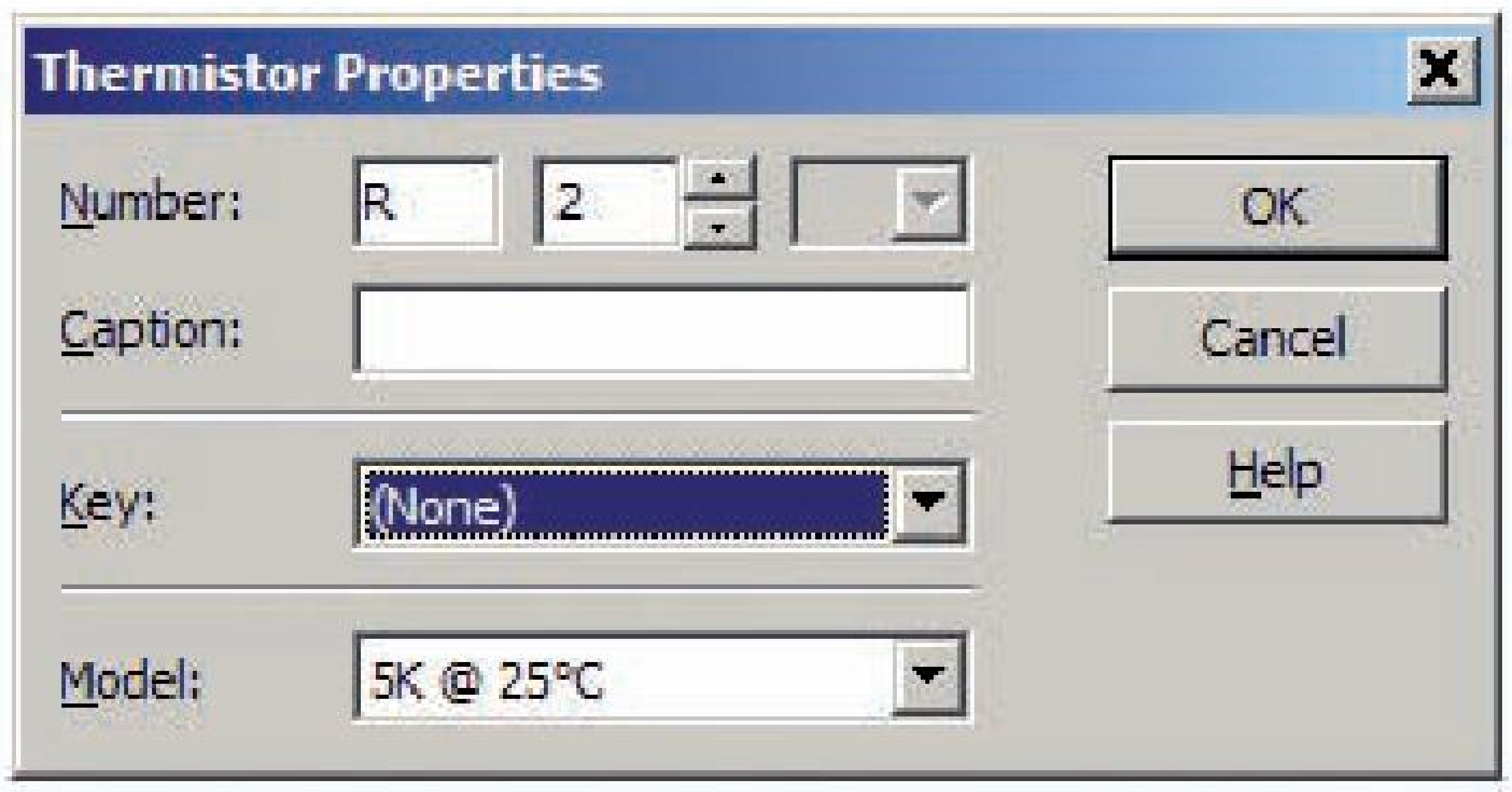
Caption:

Key: (None)

(None)
A
B
C
D
E
F
G

Model:

Fig.9. Assigning a key to the thermistor temperature



Thermistor Properties

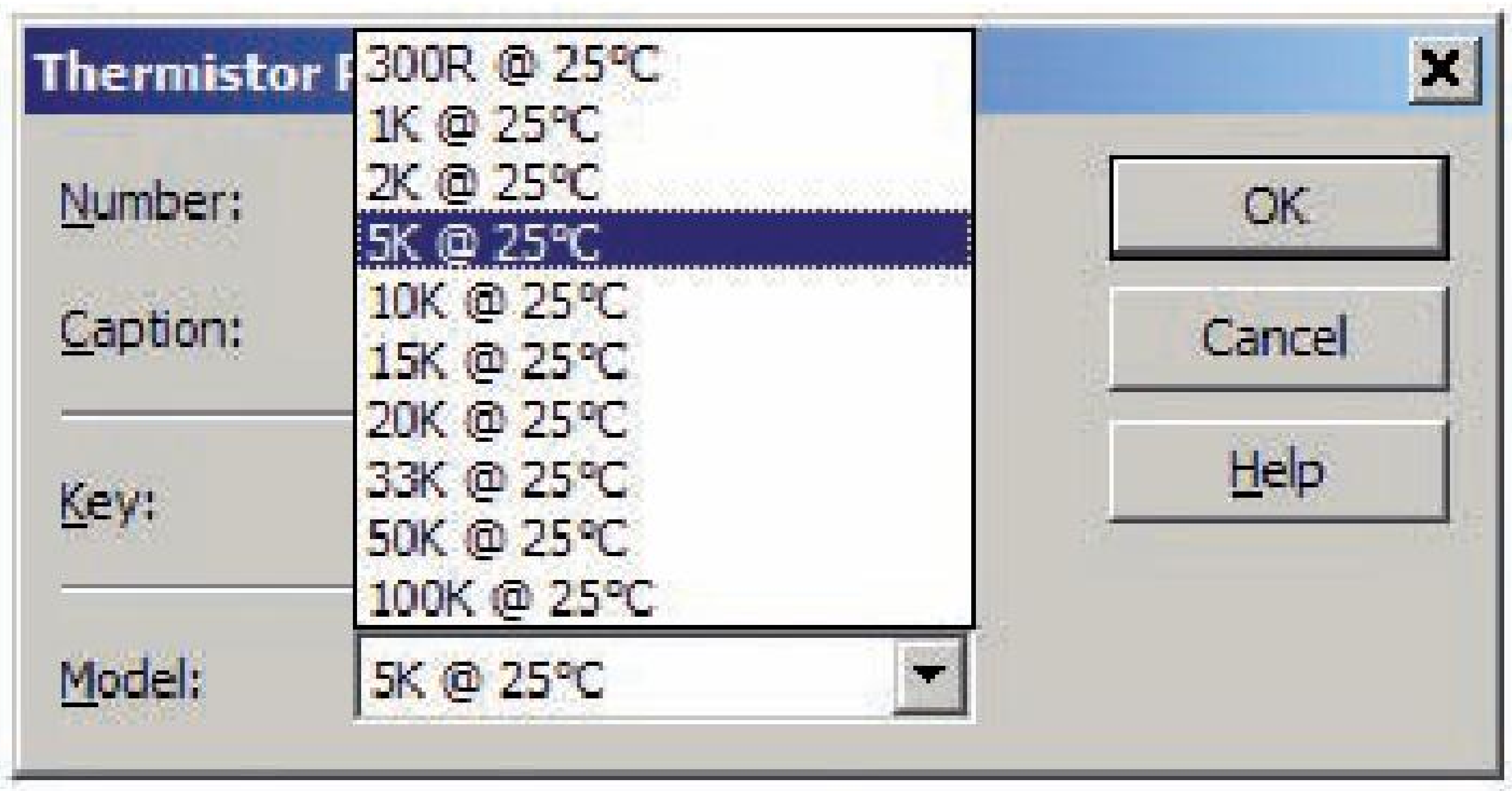
Number: R 2

Caption:

Key: (None)

Model: 5K @ 25°C

Fig.8. The thermistor properties dialogue



Thermistor P

Number:

Caption:

Key:

Model: 5K @ 25°C

300R @ 25°C
1K @ 25°C
2K @ 25°C
5K @ 25°C
10K @ 25°C
15K @ 25°C
20K @ 25°C
33K @ 25°C
50K @ 25°C
100K @ 25°C

Fig.10. Choosing a thermistor model

oscillator. The oscillator will be enabled when the voltage at pin-4 rises to the supply voltage and disabled when it falls to zero. This effectively starts and stops the astable oscillator, sounding the audible output when the output (pin 3) of the 555 goes high and off when the output goes low.

The 555 astable oscillator circuit was described previously in October 2012 *EPE* (page 50) so we will not waste any space by further describing the stage, other than to say that the square wave output signal from pin 3 is used to drive a low-cost piezoelectric buzzer.

Get real

The temperature sensing bridge that we met earlier can be easily tested with Circuit Wizard using an arrangement like that shown in Fig.7. The NTC thermistor component is available from Circuit Wizard's Gallery of components. Click on the Gallery tab, then Input Components and Sensors and simply drag and drop the thermistor into the circuit window and finally double-click on the component in order to set its properties, as shown in Fig.8.

To be able to easily vary the ambient temperature of the thermistor we can assign a key to it. Simply click on the Key field and choose a key from the drop down list, as shown in Fig. 9. Whenever the key is pressed (in this case we have chosen the 'A' key) the temperature will increase by 5°C. Using the 'Shift' key together with the chosen key (in this case 'Shift+A') the temperature will fall by 5°C. This method will allow us to experiment with temperatures over a wide range.

Next, we need to select a model for the thermistor component. This can be done by clicking in the Model field and selecting a model from the drop down list. Because this is one of the most commonly available components we have selected a model where the resistance of the thermistor is 5kΩ at 25°C (see Fig.10).

Temperature simulation

Fig.11 shows a running simulation of the temperature sensing bridge, with Circuit Wizard displaying the current temperature and resistance of the NTC thermistor and the output voltage of the bridge. If you use the assigned key to vary the temperature range you should obtain values like those shown in Table 1. You might like to complete this table for your own circuit, showing the corresponding output voltages from the bridge.

CIRCUIT WIZARD

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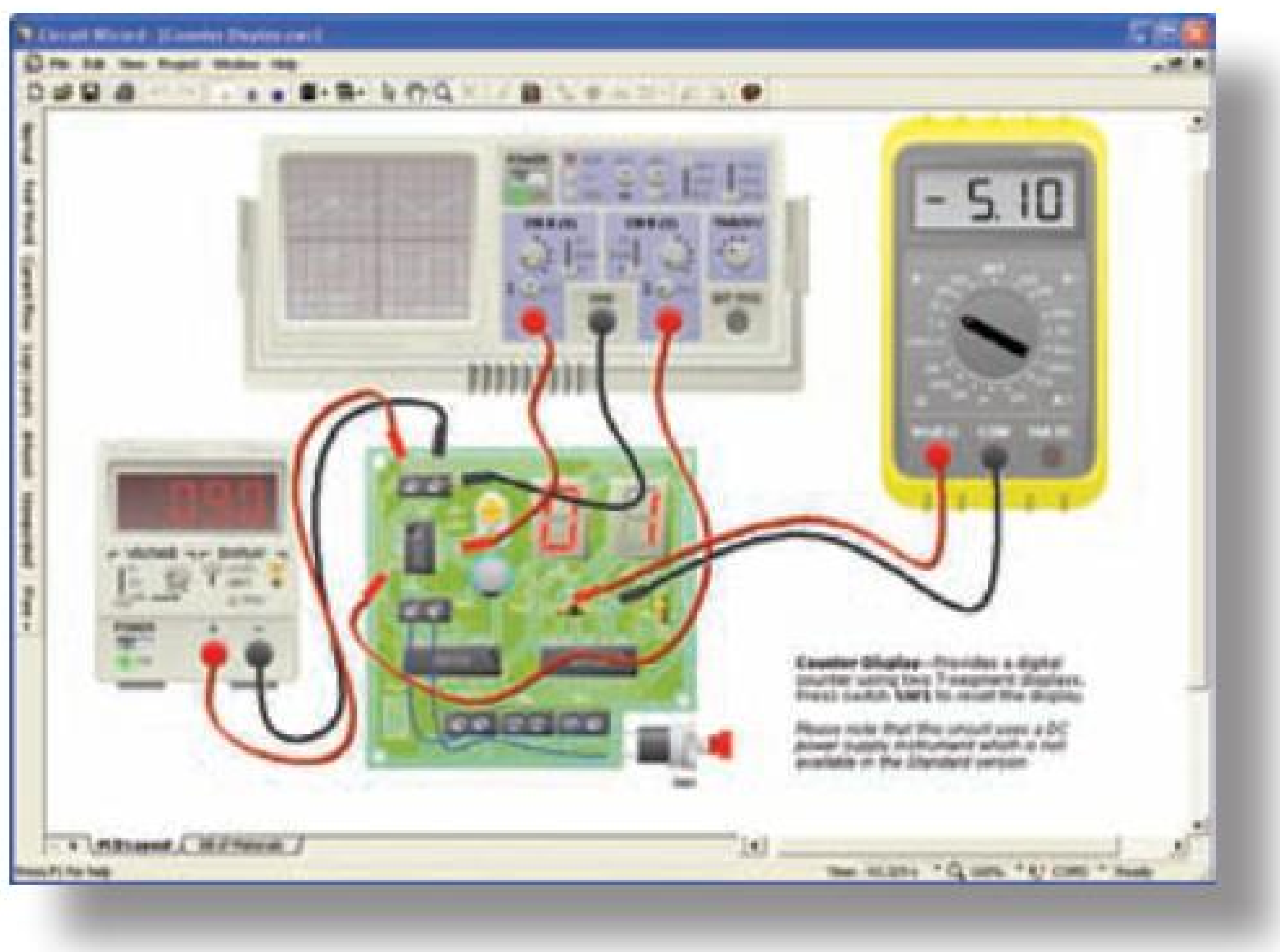

This software can be used with the *Jump Start* and *Teach-In 2011* series (and the *Teach-In 4* book).

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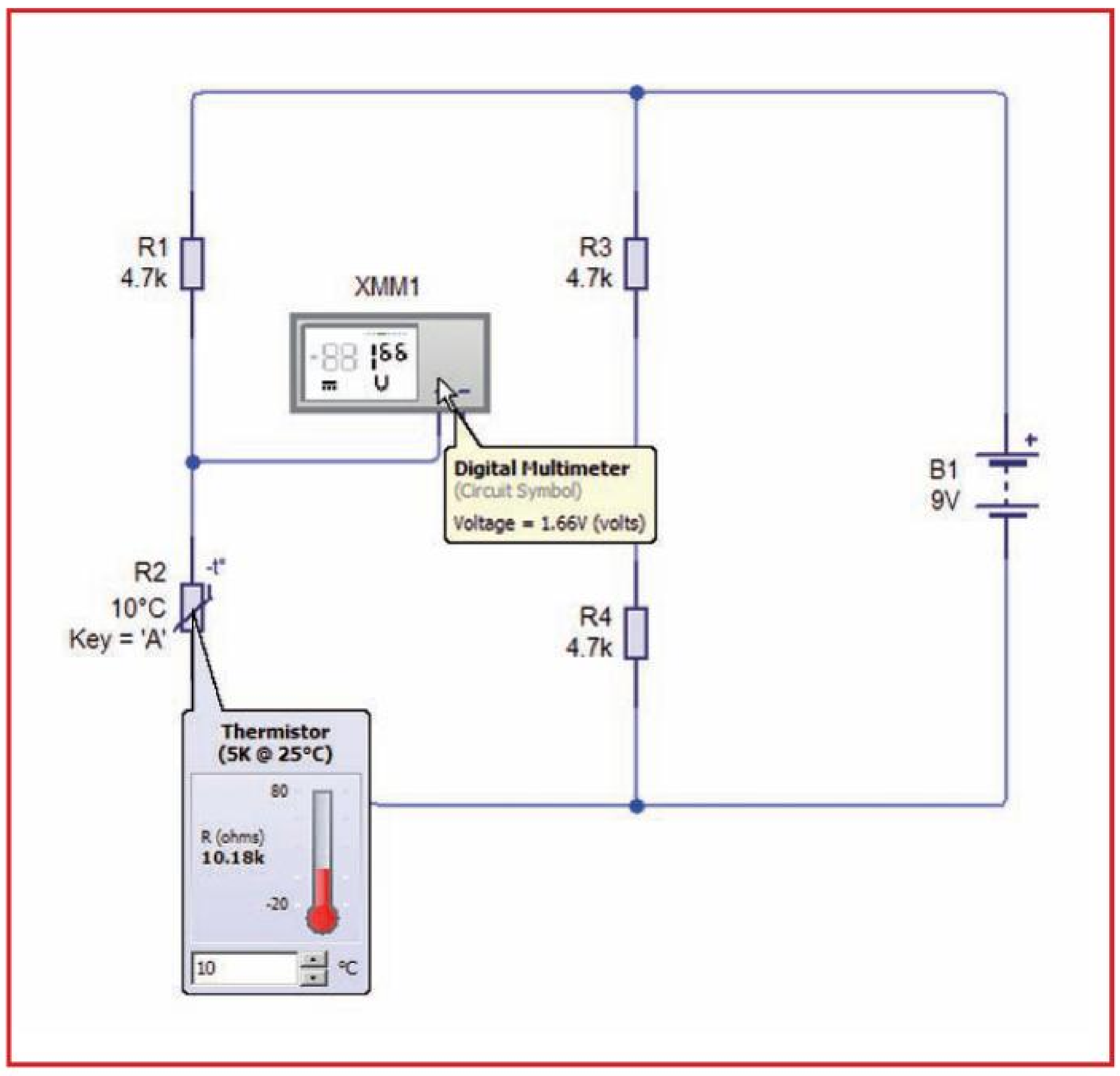
R1
4.7k
XMM1
R3
4.7k
Digital Multimeter
(Circuit Symbol)
Voltage = 1.66V (volts)
B1
9V
R2
10°C
Key = 'A'
R4
4.7k
Thermistor
(5K @ 25°C)
80
R (ohms)
10.18k
-20
10
°C

Fig.11. (left). The running simulation of the temperature sensing bridge

Table 1: Variation of thermistor resistance with temperature

Temperature, °C	-20	-15	-10	-5	0	+5	+10	+15	+20	+25	+30
Resistance, kΩ	54.29	39.97	29.78	22.43	17.07	13.12	6.29	7.96	6.29	5.0	4.01
Bridge output, V											

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Frost Alarm – using Circuit Wizard

AS USUAL, we'll now look at putting this month's *Jump Start* theory into practice to produce a working electronic product. Fig.12 shows our complete *Frost Alarm* circuit. As discussed previously, it uses a TL071 operational amplifier IC used to trigger a 555-based astable alarm (we looked at these last month). D3 (the green LED) indicates that the circuit is active, while the red LED (D2) and the piezoelectric buzzer (BZ1) are driven directly from the 555 to sound the alarm when the temperature drops below a pre-set level.

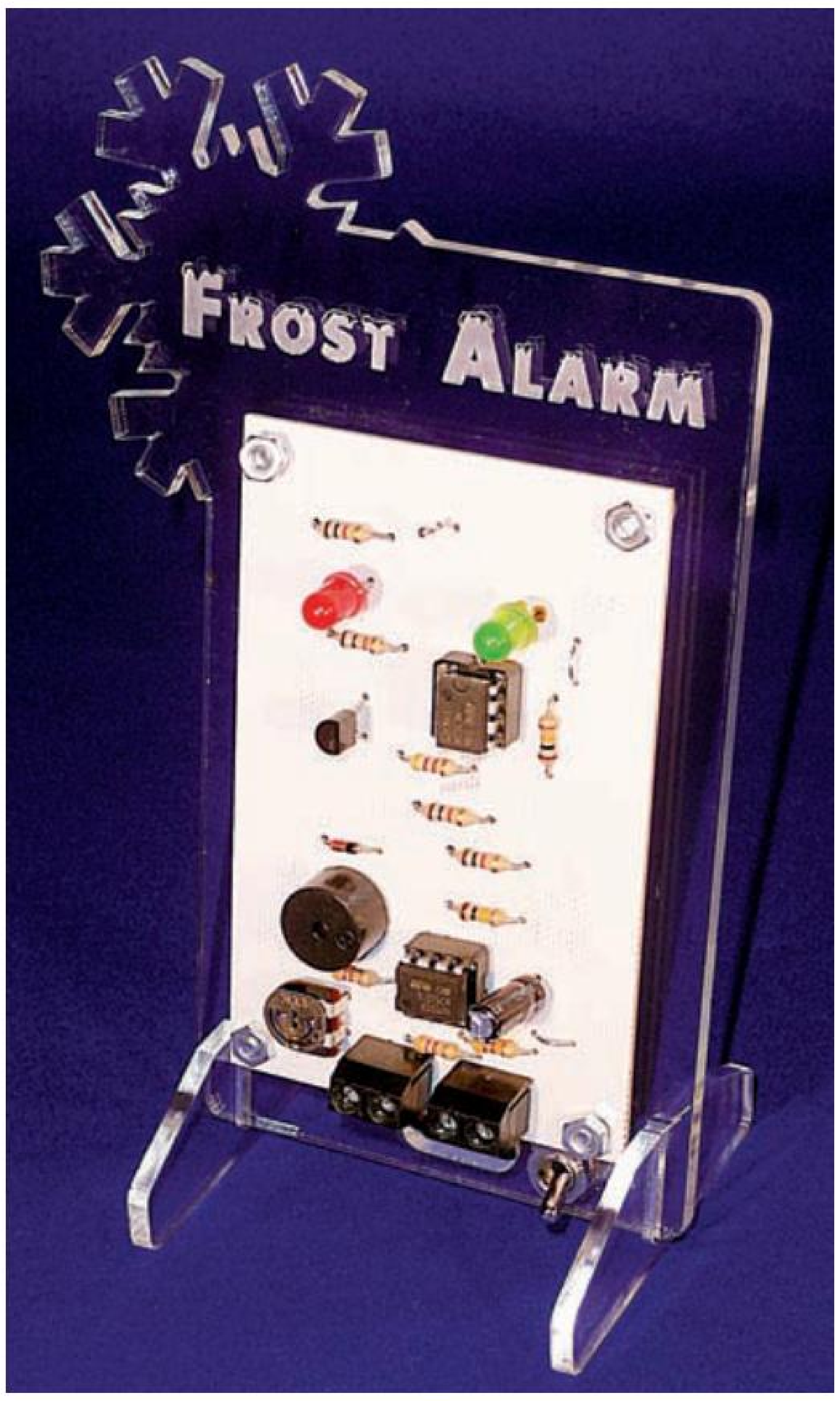
Try out the circuit by simulating it in Circuit Wizard. Note that, as before, we've assigned the 'A' key to the thermistor so that we can easily simulate changes in temperature; once again pressing 'A' to raise the temperature and 'SHIFT+A' to lower it. By varying trimpot VR1 it is possible to alter the temperature below which the alarm will trigger.

Creating a circuit board

Fig.13 shows our example printed circuit board (PCB) for the frost alarm circuit. We've placed the switch and battery connections on the bottom with the two indicator LEDs, and the thermistor on the top with the intention that when orientated upright the battery can be run below and behind a stand with the indicators evenly placed at the top of the unit.

Depending on your intended usage, you may wish to mount the PCB in a full enclosure; in particular, if you intend it for exterior use. In this case, ensure that the thermistor is positioned such that it can experience the ambient temperature. You may, for instance need to drill several ventilation holes if using a sealed-box enclosure.

For our prototype unit, we've used a laser cutter to create a snowflake-stylised backing board from clear acrylic (see Fig.14). We also cut two feet to accept the backing board and allow it to stand upright. It's a simple but attractive way of mounting the circuit that can easily be personalised and (when using transparent material) shows off all of your handiwork and soldering skills.


FROST ALARM

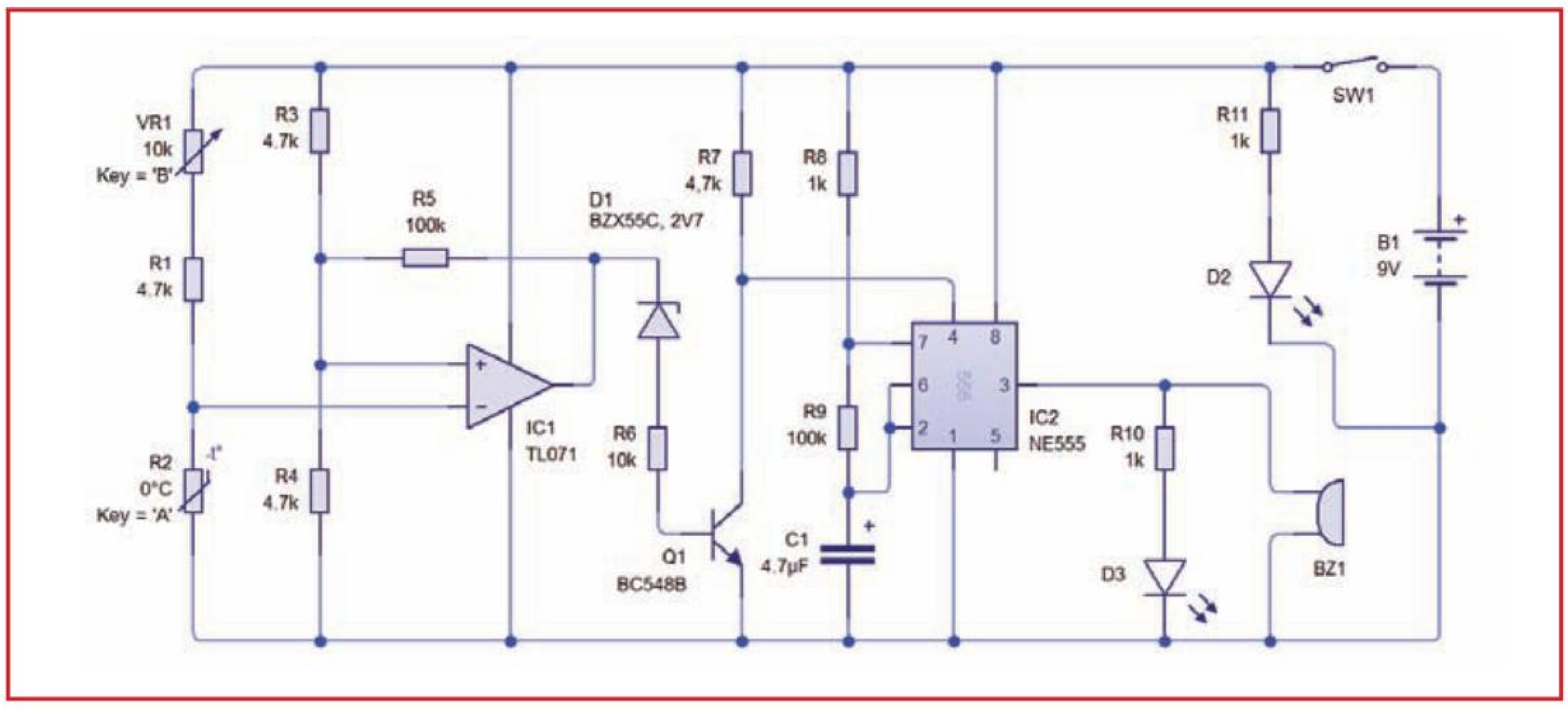

VR1
10k
Key = 'B'
R3
4.7k
R1
4.7k
R5
100k
D1
BZX55C, 2V7
R7
4.7k
R8
1k
R11
1k
SW1
B1
9V
D2
IC1
TL071
R6
10k
R9
100k
IC2
NE555
7
4
8
6
3
2
1
5
R10
1k
R2
0°C
Key = 'A'
R4
4.7k
Q1
BC548B
C1
4.7µF
D3
BZ1

Fig.12. The complete circuit diagram of the Frost Alarm

You will need...

Frost Alarm

1 PCB, code 876, available from the *EPE PCB Service*, size 90mm × 56mm
2 two-way PCB mounting terminal blocks
1 battery clip for a PP3-type battery
1 9V (PP3-type) battery
1 SPST switch (SW1)
1 miniature 6V to 9V piezoelectric buzzer
2 8-pin IC sockets

Semiconductors
1 TL071 operational amplifier (IC1)
1 555 timer (IC2)
1 BZX55C 2.7V Zener diode (D1)
1 Green LED (D2)
1 Red LED (D3)
1 BC548 *NPN* transistor (Q1)

Resistors
1 NTC thermistor (R2)
4 4.7kΩ (R1, R3, R4 and R7)
2 100kΩ (R5 and R9)
1 10kΩ (R6)
3 1kΩ (R8, R10 and R11)
1 50kΩ PCB mounting preset potentiometer (VR1)

Capacitor
1 4.7µF radial elect. (C1)

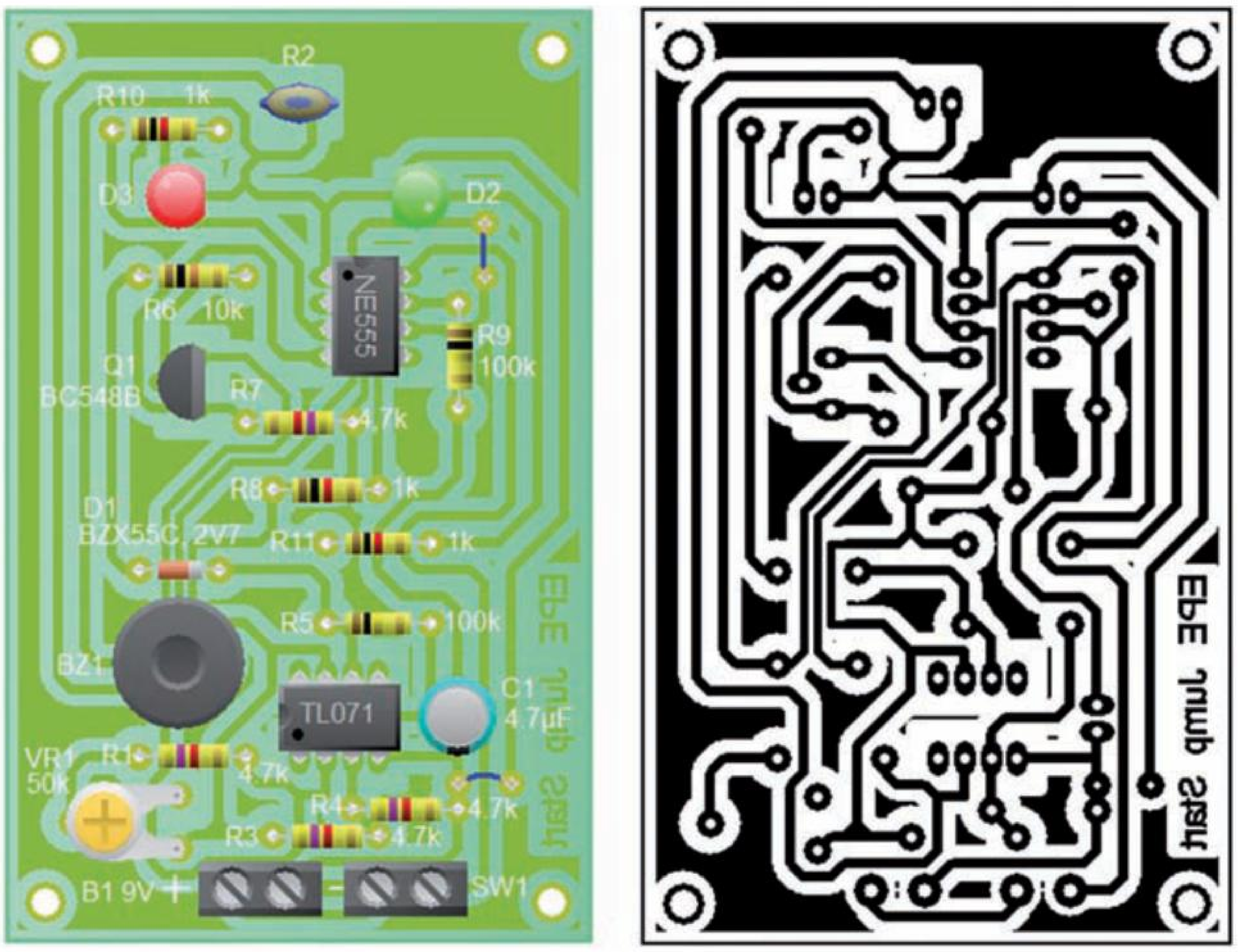


Fig.13. Frost Alarm printed circuit board component layout and copper track pattern. The final size of the prototype board is 90mm × 56mm

As the component count increases (and particularly when working with several integrated circuits) PCB designs get rapidly more complex and difficult to route. More advanced PCB routing software uses complex algorithms to automatically route hundreds or thousands of connections efficiently. Although Circuit Wizard does do a nice job of routing simple circuits, it is quickly foxed as you look at more complex circuits. In reality, rarely is consumer electronic design software able to match the intelligence and skills of a human design engineer.

If you find trying to create PCB layout frustrating then you're not alone. Many electronic students take a while to hone their PCB design skills and it can take a long time at first to get a result that you're happy with. Optimising a PCB isn't just about making it look neat. An efficient PCB design can help to increase component density and reduce the physical size of the PCB and hence reducing material costs. Good PCB design aids manufacture/assembly, while also taking into account any operational considerations of the final product.

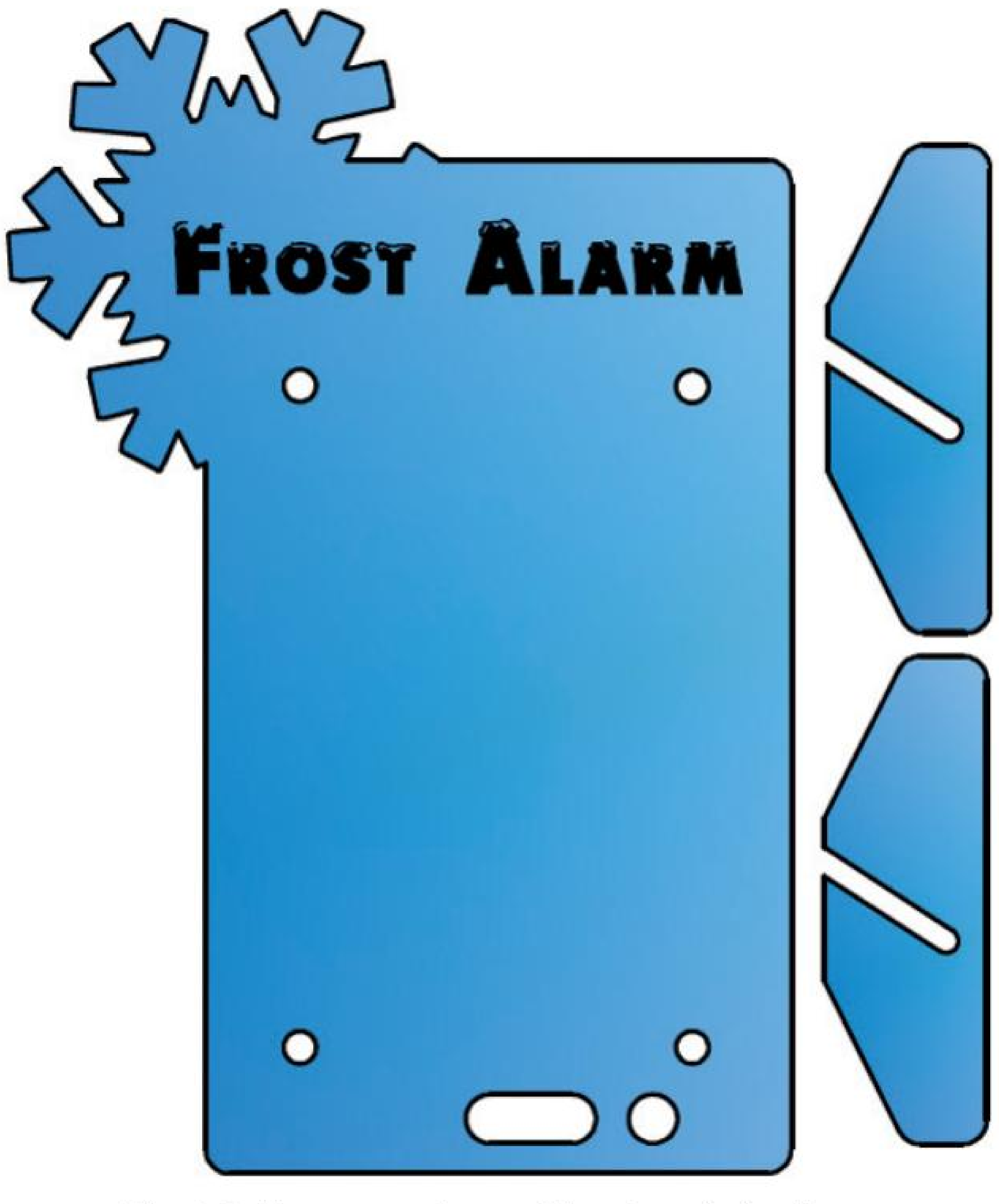


Fig.14. Laser-cut acrylic stand design

Next month

In next month's *Jump Start* we shall be getting ready for Christmas with a simple lighting controller that can be used to drive a variety of festive light displays.

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RICHARD'S HOT TIPS ON PC BOARD DESIGN

We've compiled some useful advice to help you to improve your skills

- When converting to a PCB, turn off the automated placement options and place the components yourself. Arrange and rotate the components so that they reduce the complexity of the nets (green lines) to simplify your routing process later.

In fact, by arranging the components effectively, the auto-routing feature is sometimes able to route your board for you satisfactorily after this step. Allow enough space around your components and try to think about what connections you will need to make and where you can route them as you decide on the component placement.

- Make use of your components to help you 'cross over' tracks when needed. Resistors and diodes are often wide enough to allow two or more tracks to be run between their two connections. Similarly, tracks may be run below an IC, as shown in Fig.15. You may need to reduce the track width when routing though tight gaps. Double-clicking a track or right-clicking on Properties will allow you to change the track width, as shown in Fig.16.

In low power circuits the tracks can be made relatively narrow with no impact on the operation of the circuit. However, you do need to think carefully about track width on more powerful circuits.

Keep in mind that the copper layer on PCBs is very thin and consequently the cross-sectional area of tracks is small, which affects their current-carrying ability. You also need to consider the quality of the manufacturing processes that you are using; the narrower your tracks and the smaller the gaps on your PCB the more accurate you must be in production.

- As we have discussed in previous articles, sometimes it is necessary to add jumpers or links where a track is required to cross over another and no other sensible alternative routes exist through the PCB design. Try to keep these to a minimum, as small as possible and only horizontal/vertical for neatness. In fact, wire links can actually be quite useful for fault finding by providing a convenient connection point.

- Circuit Wizard 'optimises' the nets as you move components around by suggesting the nearest common point to make the required connection. However, sometimes the nearest point might not be the most convenient to make.

If you are finding it hard to make a connection, look for alternative common points. Print out a copy of your circuit schematic so that you can cross-reference it and look for common connections.

- Always run a quality check before continuing to manufacture your PCB – don't wait until you've invested time, effort and cost making a PCB to find that it's flawed. It's also important to make sure that your circuit schematic is 100% accurate. If your initial circuit is incorrect then so will your PCB be. Therefore, always double check before starting the conversion process.

When trying to resolve an issue found by the Quality Check, turning on pin numbers (View > Display > Pin Numbers) will help you to trace the fault. The Quality Check can be a little confusing to interpret and can make a simple problem such as a missed connection or touching track/pad look more complex than it is.

The Quality Check describes the whole common set of connections that contains an error. It details the connections that you have made on the PCB, stating that this differs from the circuit diagram.

Your task is, therefore, to try and identify what the difference is. In practice, we have found that a good strategy is to compare the Quality Check to the original circuit diagram to identify the problem, then return to the PCB to try to resolve it.

- Single-sided PCBs do have a ceiling in terms of the circuit complexity that they can sensibly support. If you are working with more advanced circuits you might like to look at using a double-sided board. However, this does add more complexity to the manufacture and assembly process, and you may not have the capability to do this. If you cannot produce these yourself there are several companies that offer PCB manufacturing services. Often, you simply upload or e-mail your artwork and requirements and they will do the rest. Circuit Wizard is able to output your designs in several formats, including the industry-standard Gerber format, which is suitable for commercial manufacture.

- Finally, stay calm, don't get frustrated, work logically through your circuit and if you come to a sticking point take time to find a solution. Try looking back at earlier connections that you've made and see if you can amend them in order to help you complete one that is being particularly difficult. Some students find it useful to print out their designs as they work. By looking back at these printed designs you will often be able to spot a simple change that will allow you to progress further with your PCB layout.

Finally, when it comes to designing PCBs, practice really does make perfect. Our *Jump Start* series will certainly provide you with plenty of opportunity to develop your skills by designing, testing and building a range of simple circuits.

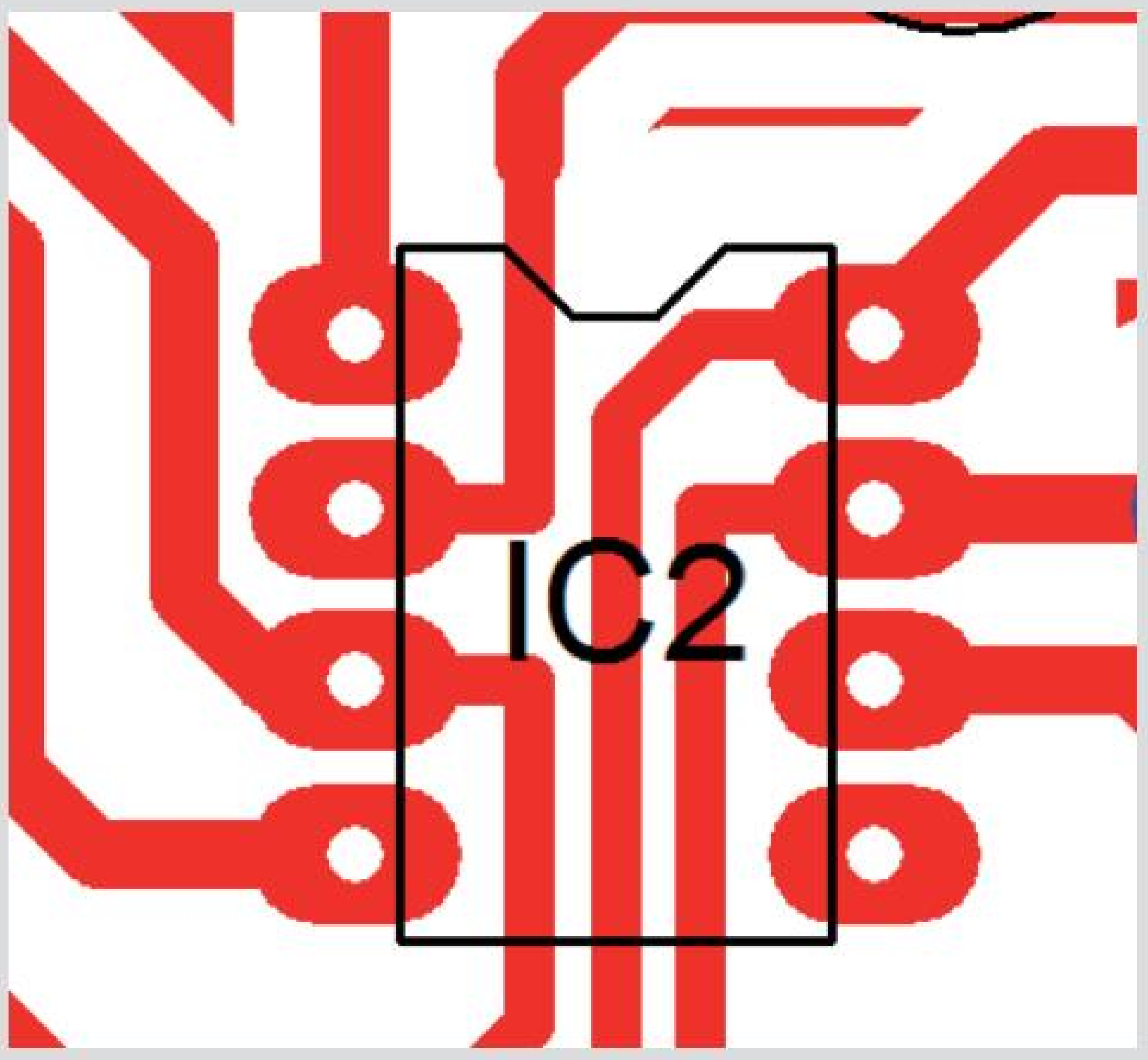
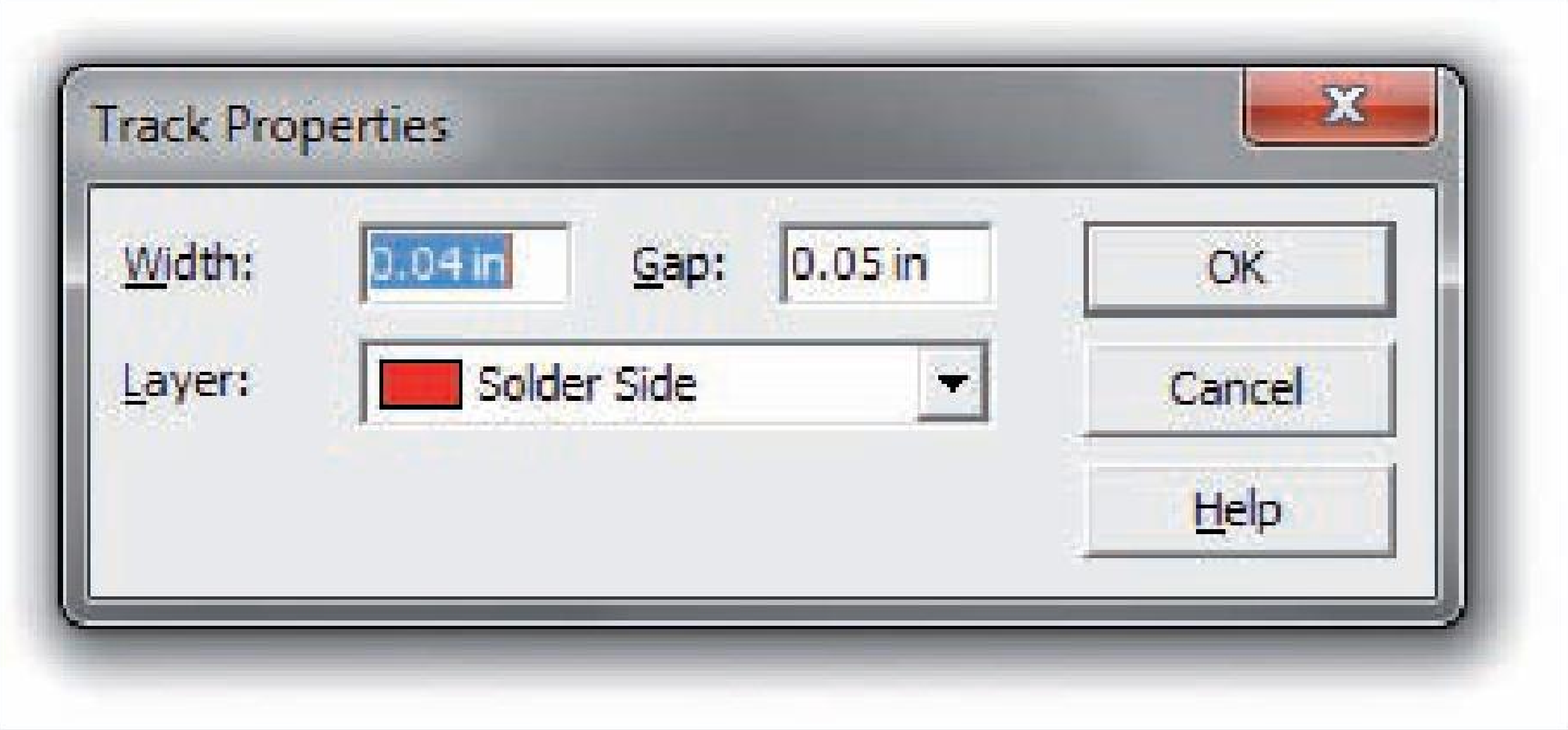


Fig.15. Running tracks below an IC


Track Properties

Width: 0.04 in
Gap: 0.05 in
Layer: Solder Side

Fig.16. Using the Track Properties dialogue to change the width of a PCB track

Special thanks to Chichester College *for the use of their facilities when preparing the featured circuits.*

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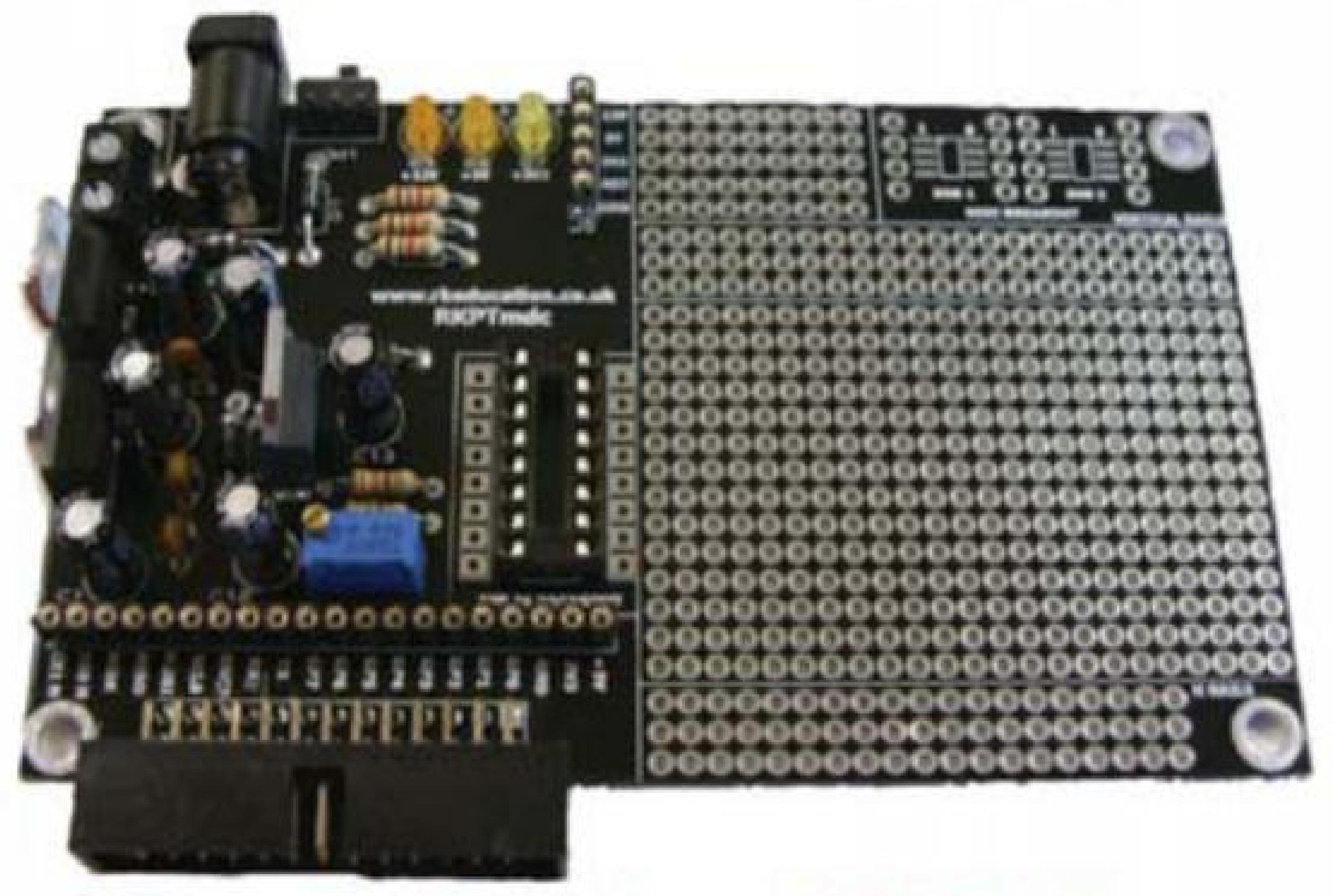

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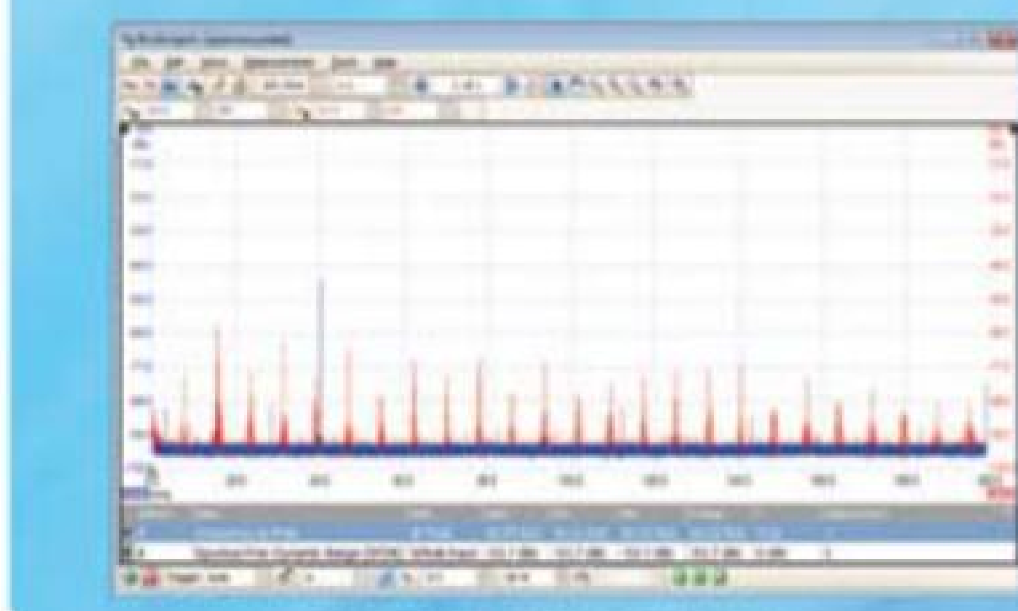
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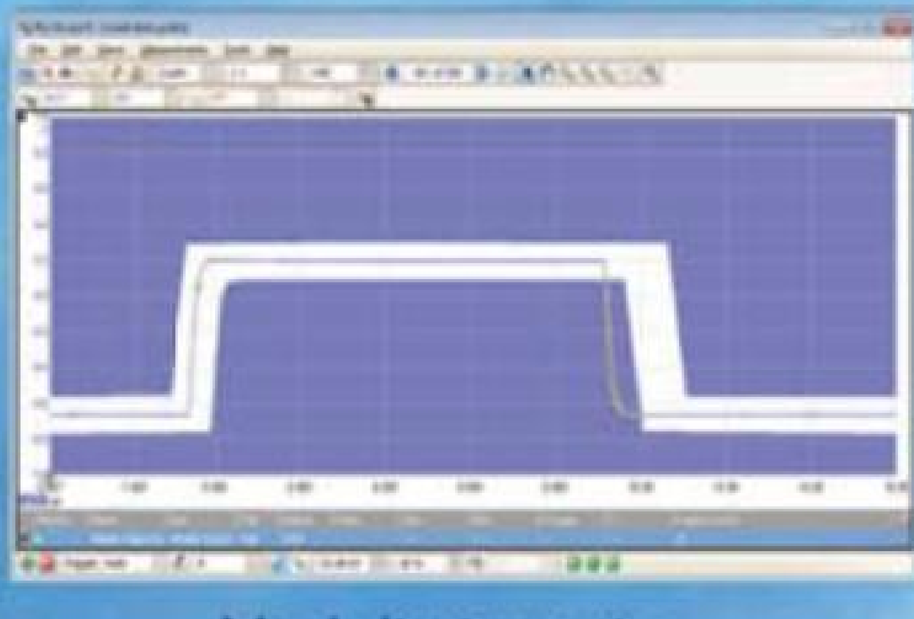
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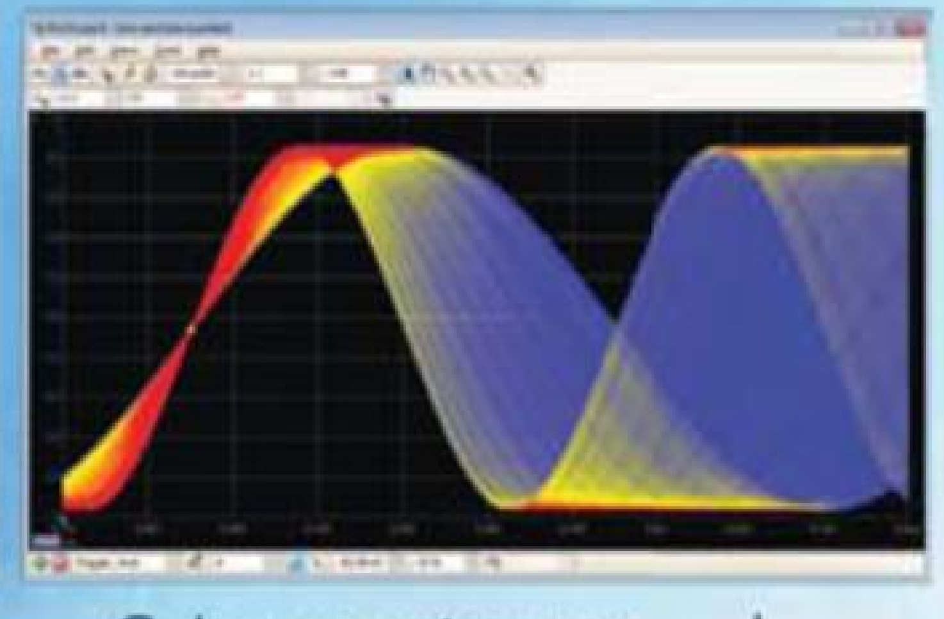
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Max's Cool Beans

By Max The Magnificent

Generally speaking, I think it's fair to say that I really am not a covetous person. If I see someone with a big car or a large house or a humongous flat screen television I think 'That's nice,' and then carry on with whatever I was doing or thinking about before. But, having said all this, there are two things that I am currently drooling over...

I want a 3D world globe display

This all started when one of our friends recently adopted a little girl from China. A few days ago my wife mentioned to me that she had been visiting with our friend when the six-year-old child was learning English and had pointed at herself and said something like 'From China.'

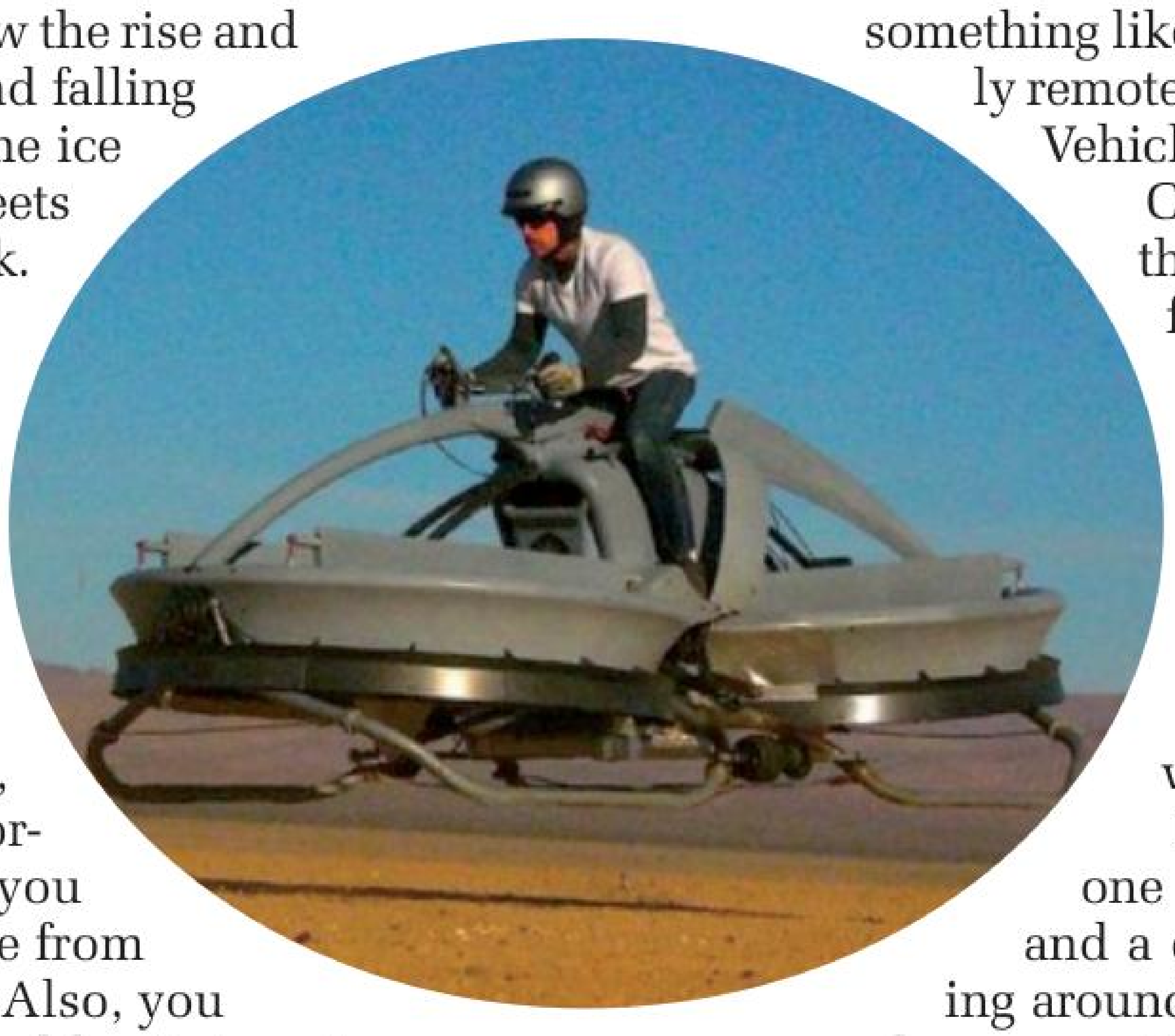
I said that it would be handy for them to have a world globe so that they could show the kid where she's living now and where China is and so forth. This reminded me that I have an old 18-inch globe in the cupboard in the study, so I wandered off to find it.

I was fully expecting to give the globe to our friend as a gift, but I had forgotten just how interesting these things are. Returning from the study, globe in hand, I was idly spinning it, noticing all sorts of interesting things, like just how big Africa is compared to North America when you compare them on a spherical projection.

The reason I'm waffling on about this here is that I began to ponder the creation of a 3D spherical display. Something about two to three feet in diameter made out of some translucent white plastic material. Inside there would be some form of projector (maybe multiple Pico projectors) presenting images, animations, videos, and textual data onto the surface of the sphere.

The really interesting part comes when you start to think about the various types of information you might present on such a display. For example, you could show animations of how plate tectonics has caused the continents to drift around the surface of the Earth over the last billion years or so. Also, you could show the rise and spread of life on earth, rising and falling sea levels, and simulations of the ice ages when mile-high ice sheets reached as far south as New York.

How about displaying animations of human migrations, or the rise and fall of ancient civilizations, or the spread of different forms of government like democracy and communism? And you could present current data, like weather systems, plane flights and/or satellite orbits (with fading contrails so you could see where they had come from and where they were headed). Also, you could display real-time data like Internet traffic and the spread of computer viruses (or human viruses for that matter).



Or how about troop movements and suchlike during the Second World War? What about computer gaming scenarios like the game of Risk, but much more detailed. Or how about a 'Planet Builder' application where you specify initial conditions (core temperature, materials, and so forth) and you evolve your own planet and life forms and suchlike?

And we wouldn't have to restrict ourselves to only displaying Earth-related information. We could make our display look like the Moon, or Mars, or Jupiter, or the Sun, or… I tell you; once you have the idea of a 3D globe display, new ideas keep on popping into your head, and it seems that there are endless applications for such a beauty.

I'm also pondering the control of this beast. Maybe some form of capacitive sensing like an iPad, or perhaps gesture recognition like a modern machine-vision equipped computer game. By simply passing your hand across the face of the globe you could cause the information being displayed on its surface to rotate. Or by spreading your fingers (like a 'zoom-in' gesture on the iPad) you could cause a magnifying-glass effect to appear – that is, an image of the outside of a magnifying glass could appear centered on your fingers and the area under this magnifying glass could show a zoomed-in view … and you could keep on zooming in just like on Google Earth, except that your zoomed-in region would be presented in the context of the rest of the globe.

I want a Hover Scooter

But wait, there's more… do you remember that Star Wars movie *The Return of the Jedi*? At one part of the film, our heroes take off flying through the forest on flying scooters with those naughty Stormtroopers chasing them. I must admit that when I first saw this film, there was a little voice at the back of my mind saying 'Oooh, I want one of those!' (Actually, it was probably my unconscious mind saying 'Oooh, Shiny!', but the end effect was the same.)

Of course, I'm not a complete idiot (my mother had me tested). Even I knew that the chances of anyone creating something like this in my lifetime were exceedingly remote. But then I saw an article on a Hover Vehicle from a company called Aeroflex.

Come on… you have to admit that this is uber-cool. I live in a relatively flat area, and I can easily visualize myself zipping around our neighborhood with my 17-year-old son and his friends looking on in envy. Of course, I would wear much more stylish head gear than that shown in this image – I'm thinking my rainbow-colored Beanie hat with the propeller on top.

I cannot tell you how much I want one of these little beauties. In fact, I and a couple of friends have started looking around for a supplier of these ducted fans and we are actively pondering how one would implement a sort of fly-by-wire control system, As always, watch this space…

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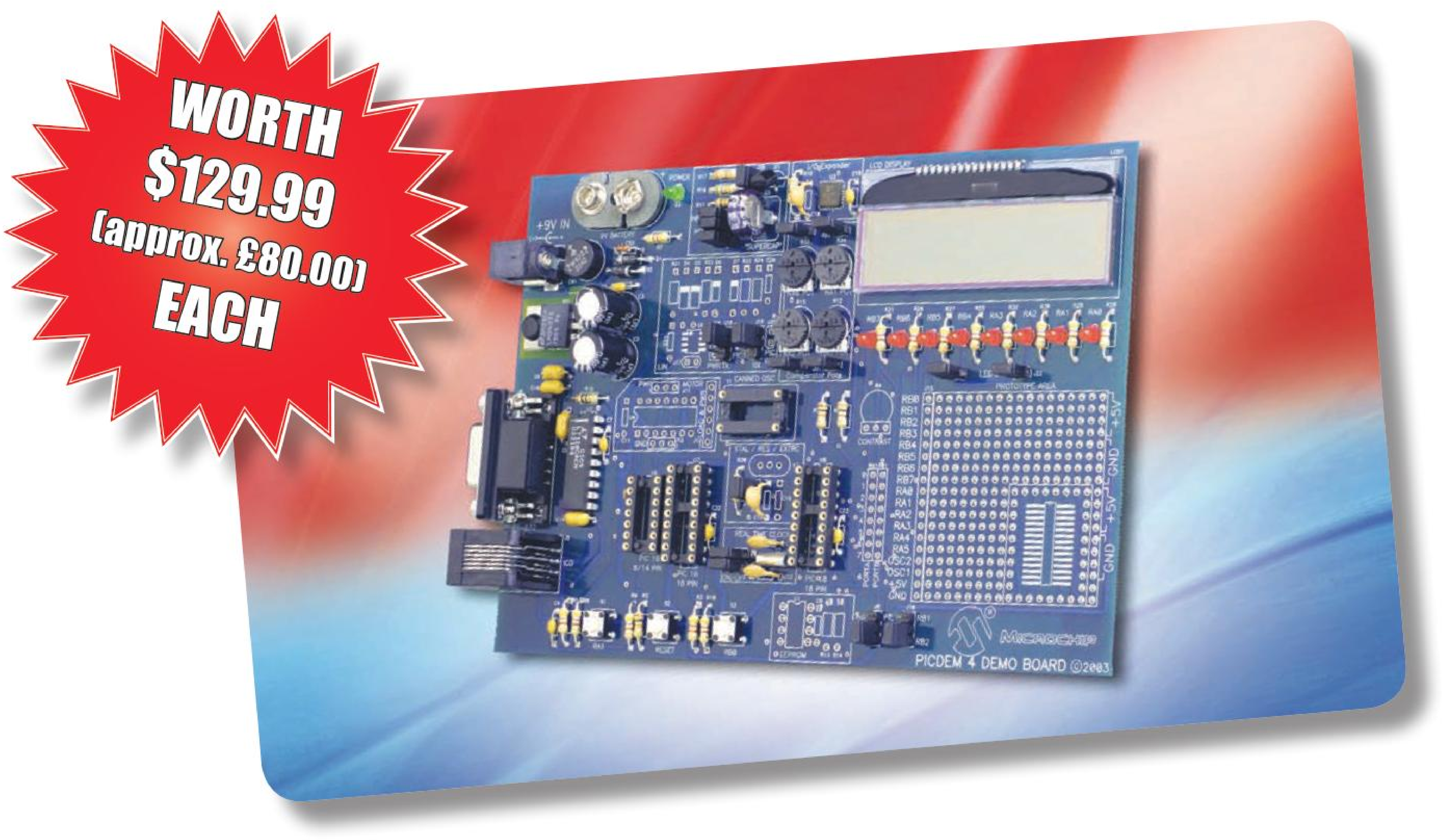

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The only auto-dialler you'll ever need!!

THIS is a wonderfully simple, but effective auto-dialler – and what's more it should cost less then a fiver (say USD 8)

Many years ago, I built an auto-dialler that was able to call up to six pre-programmed numbers on a rotational basis and deliver one of two messages – fire or intruder – depending on what had caused the alarm to be triggered. It also had an instant hold message that would give the primary message tape time to start or the listener time to figure out what the call is about.

My auto-dialler never made a call in anger or panic. However, a few months ago when it was zapped for the third time by a lightening surge I decided on an update, cutting out the telephone wires, multi-number dialling and messages, using just my mobile phone number.

Design

I used the attached circuit (Fig.1) and an old mobile phone. It couldn't be simpler, but care is needed when handling the phone. If a 'hands-free kit' is available, which can enable calls, then so much the better; otherwise, proceed as follows.

First, remove the keypad cover to gain access to the area of the 'Send' button PCB terminal. Remove the small metal disc or resistance material that is used to bridge the gap on the PCB (printed circuit board) when a call is made, and carefully attach fine flexible wires to both copper track terminals – don't forget to remove the battery when carrying out this process!

Refit the battery, switch on and make a test call by momentarily touching the free ends of the two wires together, replace the keypad cover and secure the wires to prevent damage by pulling.

Nearly all readers are familiar with the 555 timer IC. I have used the dual version, a 556 timer IC. The first timer is wired as a very slow running oscillator that is used to trigger the second timer through transistor TR1. The auto-dialler must be fed from the alarm generator (siren) supply via a suitable fuse, and as such does not use any standby current as it only operates when a call is to be made.

Operation

Both timers are triggered on by the initial surge of power when the alarm operates, but while timer 1 is settling down and capacitor C1 is charging, timer 2 has already performed it's duty by powering pin 1 of the opto-coupler (IC2), thus making the first call. As IC1 pin 5 goes low, timer 2 is again triggered for about 1.5 seconds, or about the same time it would take to press the send button, through TR1 to bring the phone to 'Last Number

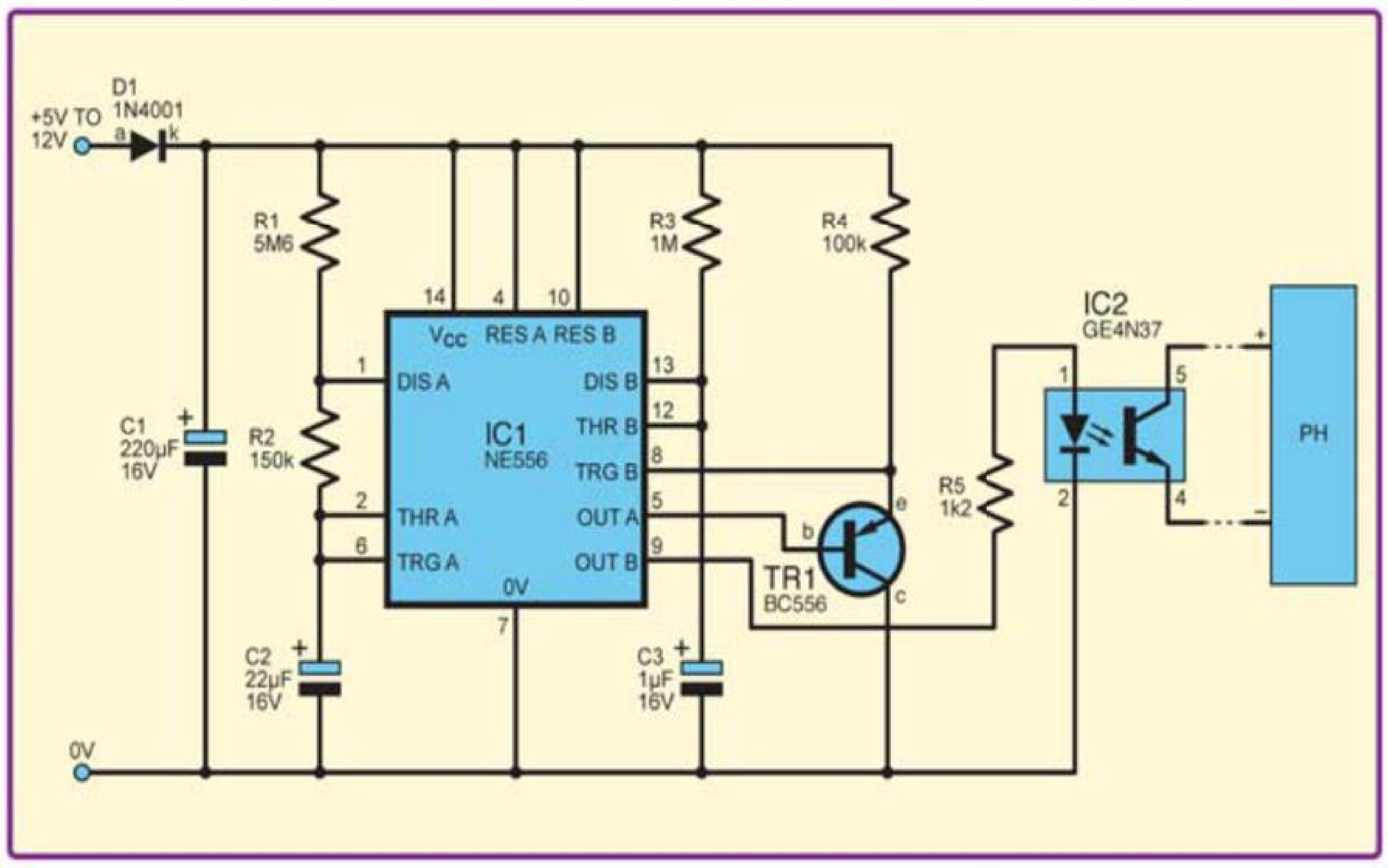

Fig.1. Circuit diagram for the Low-cost Auto-Dialler

Redial' (LNR) or to make the next call, depending on the phone used and also the setting.

The phone I used was obtained from a junk shop, and made by an Indian company called LAVA. I have no idea what the model number is, but the main thing is it was very cheap. This phone, when set to 'Contacts' pages allow calls to the selected number every time the send button or IC2 operates, but a Nokia 6100 or 6210 will have to bring up LNR, then call at the next shut down of timer 2, making it twice as long or 3 minutes between calls with the component values used for timer 1.

I find this auto-dialler more efficient than ones that just send a text message, which can, of course, get delayed – not what you want in an alarm system! Also, if you are in a tunnel, then the chances are that the alarm will still be running and making calls when you exit the tunnel.

This unit can be used anywhere and is also ideal as a silent vehicle alarm.

Phil Foster, Jamaica

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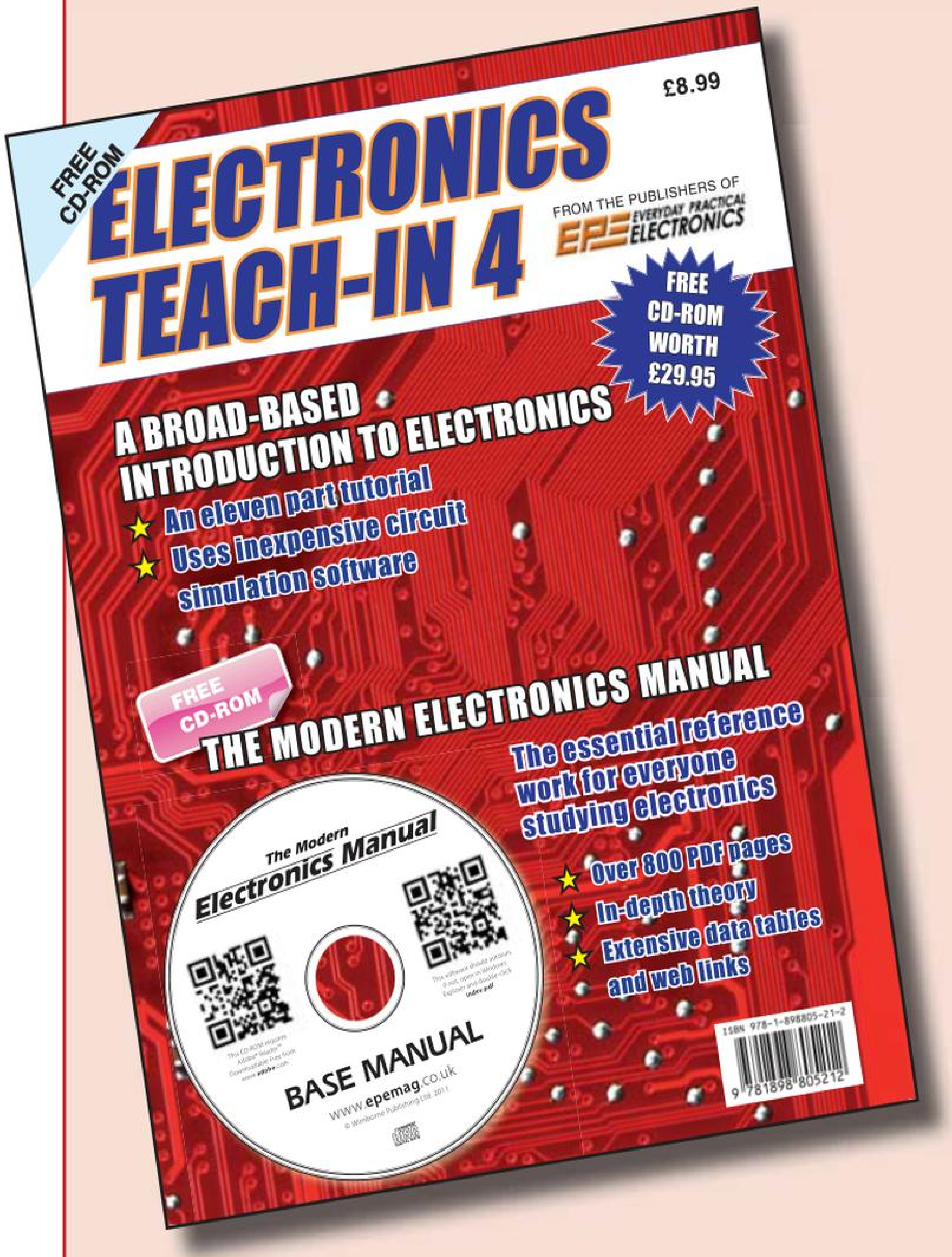
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BY IAN BELL

Early effect and Early voltage

THIS month we looks a question about bipolar transistor characteristics posted on *Chat Zone* by **lost**.

Is the Early effect, which gives rise to h_{re} *(*dV_{be}/dV_{ce}*), related to the Early voltage which gives rise to* h_{oe} *(*dI_c/dV_{ce}*)?*

This question raises a number of issues which we will look at in this article and next month. What are the 'Early effect' and 'Early voltage'? How do they affect transistor operation and circuit performance? How do we represent these effects using transistor models when we perform circuit analysis and design calculations?

Early effect

The Early effect is named after the engineer James Early (1922–2004), who, in the 1950s, worked on measuring and improving transistor characteristics at Bell Laboratories in Murray Hill, New Jersey, USA. In 1952, he published a paper titled *Effects of Space-Charge Layer Widening in Junction Transistors* on what was to be called the 'Early Effect'. For further information, there is a memorial web page for him at: **www.smecc.org/james_m__early.htm**.

Before going into the details, it is worth clarifying that lost's question refers to two different transistors parameters: h_{re} and h_{oe}. h_{oe} is a transistor's output conductance (so $1/h_{oe}$ is the output resistance), and h_{re} is the reverse voltage gain. We will discuss these in more detail next month. Both these parameters represent deviations from what we might regard as an ideal transistor, which are caused (at least in part) by the 'space-charge layer widening' effect detailed in Early's paper.

'Early effect' can refer to the space-charge layer widening effect in general, but often usage of the term is related just to transistor output conductance. This is because the impact of reverse voltage gain on transistor performance is often very small and can, therefore, be neglected when analysing circuits. However, there are circumstances, typically in radio frequency circuits, where the effect of the reverse voltage gain is significant.

Early voltage

The Early voltage is very directly associated with output conductance, but is not typically discussed in the context of reverse voltage gain. The value of transistor output conductance (or resistance) can be related to the Early voltage by a simple equation.

Thus, lost's question could be modified into a statement as follows: the Early effect gives rise to both h_{re} and h_{oe}. The value of h_{oe} is directly related to the Early voltage.

In brief

To gain an understanding of the Early effect we need to look at the physics of semiconductors, such as silicon. We will give a simplified description of transistor physics which accounts for the Early effect. In this discussion we assume (where relevant) a transistor is used in common-emitter configuration – as in the basic transistor amplifier in Fig.1 – in which the base is the input and the collector is the output, with base current controlling the collector current.

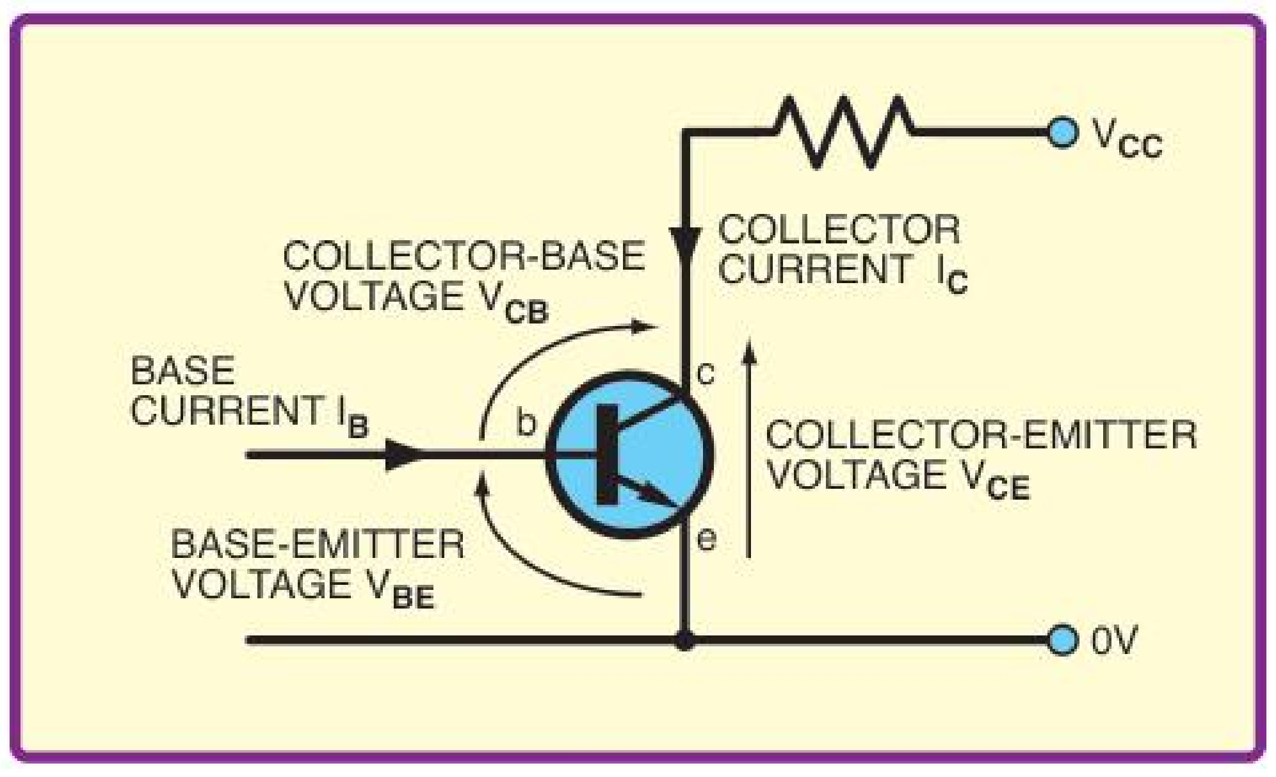

Fig.1. Basic NPN *common-emitter amplifier*

In a crystal of pure silicon, the four outer electrons of each silicon atom are involved in forming bonds with neighbouring atoms. These bonds can be broken by thermal energy, freeing the electrons to move and thus allowing electrical conduction to take place. As the temperature increases, more electrons are released and the silicon becomes more conductive. However, due to the regular and strong nature of silicon's crystal structure very few electrons break free, so very little conduction takes place in pure silicon (at room temperatures) – it is therefore a very poor conductor.

When an electron does break free of a bond, it will behave as a negatively charged particle moving through the crystal under the influence of any applied electric field. It will also leave a vacancy in the silicon crystal's bonding structure. A freed electron will move until it finds another vacancy, at which point it may drop back into the inter-atomic bond at that point. The vacancy can be viewed as having moved in the opposite direction to the electron.

In fact, the vacancy behaves like a positively charged particle, referred to as a *hole*. When an electron drops back into a bond both the hole and electron involved cease to be part of the conduction process, this is known as *recombination*. In pure silicon, electrons and holes are formed as pairs, so the numbers of holes and electrons are equal.

Doping

The key to making electronic devices such as diodes and transistors is to add very small amounts of impurities to the silicon, a process known as doping. If the impurity has five electrons in the outer part of the atom (eg, phosphorus) then four of these electrons form bonds with neighbouring silicon atoms, leaving the fifth electron unused. This electron needs much less energy to get it involved in conduction because a strong bond does not have to be broken, thus adding such an impurity greatly increases the conductivity.

The fifth electrons from these dopants do not form corresponding holes when they take part in conduction. However, some holes will be present in the material due to the same thermal process which occurs in pure silicon. The electrons outnumber the holes and are referred to as the *majority carriers*. The holes are *minority carriers*. Silicon doped in this way is referred to as *N*-type because the majority carriers are negatively charged electrons.

Doping can also be performed with an element such as boron, which has only three electrons in the outer part of the atom. This will leave a vacancy in the crystal bonding structure, which acts as free hole, so again the conductivity increases greatly. Silicon doped in this way is called *P*-type and has holes as majority carriers, and electrons as minority carriers.

Things get particularly interesting when a single crystal of silicon is doped such that it is *N*-type on one side of a boundary and *P*-type on the other side. This is known as a *PN* junction. If we make a (non-*PN*-junction-forming) electrical connection to the silicon on both the *P* and *N* sides of the junction we get a diode. The non-junction forming connections are referred to as ohmic contacts and can be made using metal wires.

When a *PN* junction is created, some electrons will move across the boundary from the *N* side to the *P* side (due to the thermal energy they possess). Here they will tend to drop into the vacancies formed by the *P*-type dopant (a recombination process). These recombining electrons are negatively charged, so this process causes a build up of negative charge in the *P*-type silicon near the junction. This is the 'space charge' referred to in the title of Early's paper and is shown in Fig.2.

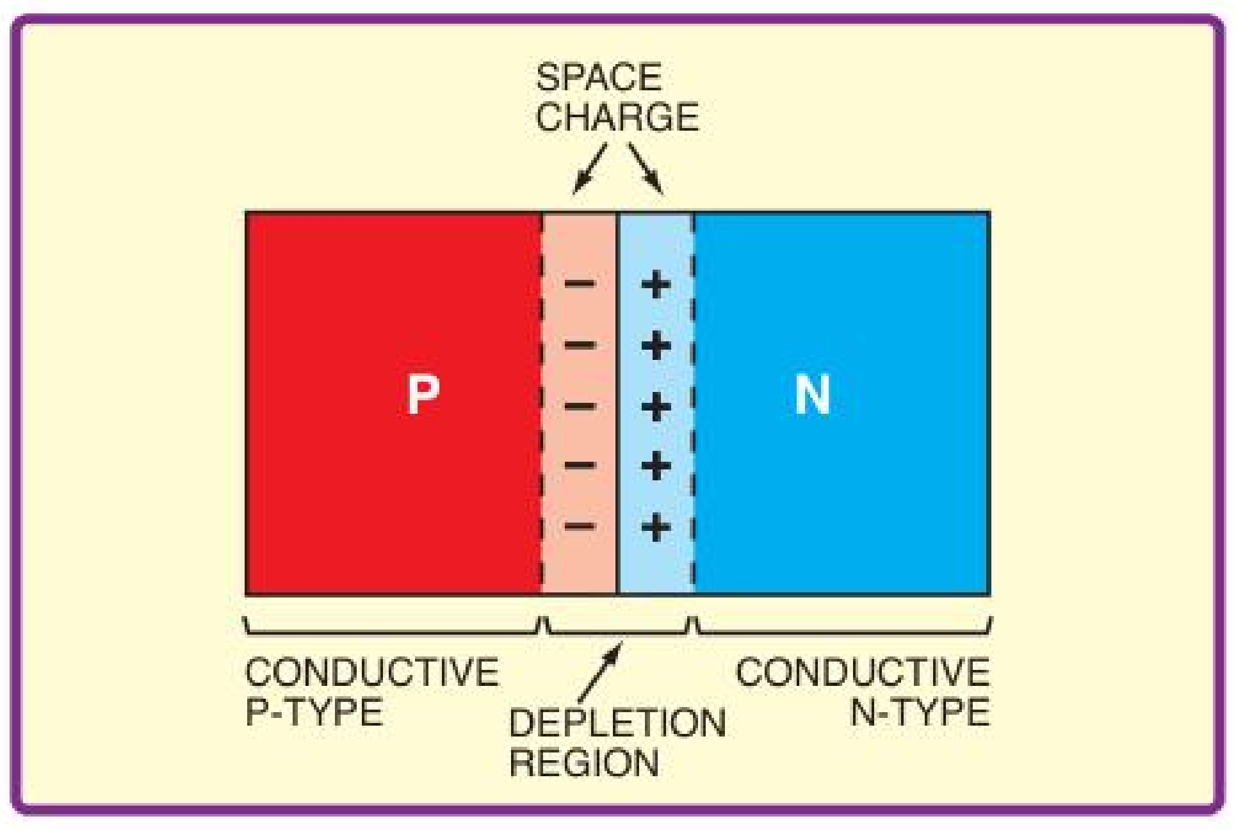

Fig.2. Open circuit (unconnected) PN *junction*

Equal polarity charges repel, which will tends to counter the space charge build up. Thus, in the *P*-type silicon we have two opposing processes – the attraction of the electrons (from the *N*-type silicon) to the gaps in the crystal structure and repulsive force of equal polarity charges. Net charge movement occurs until these processes are in equilibrium. A similar thing occurs with holes moving from the *P*-type into the *N*-type near the junction and causing a build up of positive charge.

The recombination which occurs near the *P-N* boundary as holes move into the *N*-type and electrons into *P*-type depletes the region near the boundary of charge carriers – it is therefore referred to as the *depletion region* (see Fig.2). The depletion region has very low conductivity due to the lack of available charge carriers.

If we have ohmic connections (wires) to our *PN* junction (as in a diode) and we apply a voltage to the junction so that the *P* side is negative with respect to the *N* side, as shown in Fig.3, more electrons will be pulled away from the junction in the *N* side and more holes will be pulled away from the junction on the *P* side. This will increase the width of the depletion region and very little conduction will occur – the diode is *reverse biased*. Any conduction which does occur will be due to thermally generated holes in the *N*-type, and thermally generated electrons in the *P*-type, that is, it is due to the minority carriers.

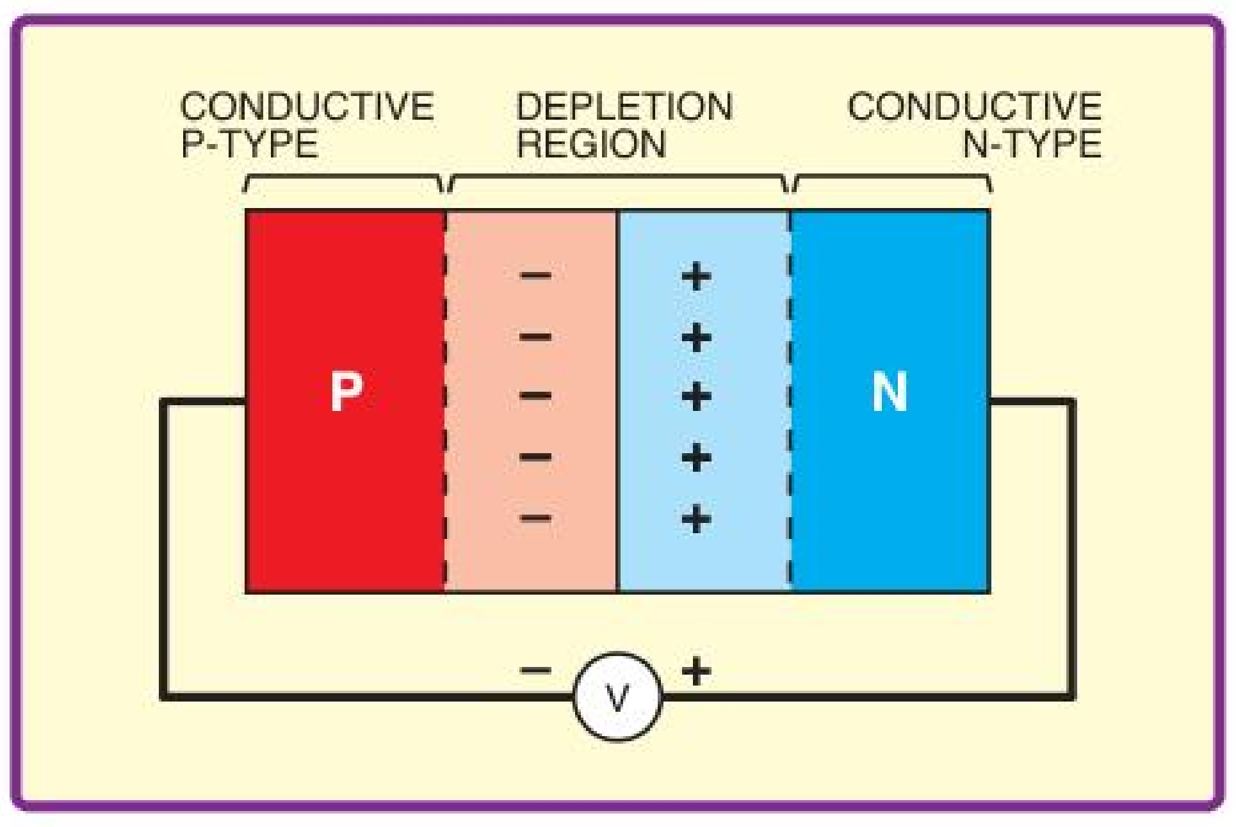

Fig.3. Reverse biased PN *junction*

If we apply a voltage to the *PN* junction so that the *P* side is positive with respect to the *N* side, then electrons will be attracted across the boundary from the *N* side to the *P* side. Conduction can occur and the diode is *forward biased*. On arrival in the *P* side, the electrons are minority carriers, so this process is called *minority carrier injection*, which is important in transistor operation. Similarly, holes move from the *P* side to the *N* side (where they are minority carriers).

Application of a forward bias voltage reduces the size of the depletion region, as shown in Fig.4, and if sufficient voltage is applied it will effectively disappear. As the applied voltage is increased from zero, the current will remain small while a significant depletion region still exists, because of its very low conductivity. Once the depletion region can no longer prevent conduction, the resistance of the junction reduces greatly – this is the 'turn-on' voltage of the diode, which is around 0.6V for silicon.

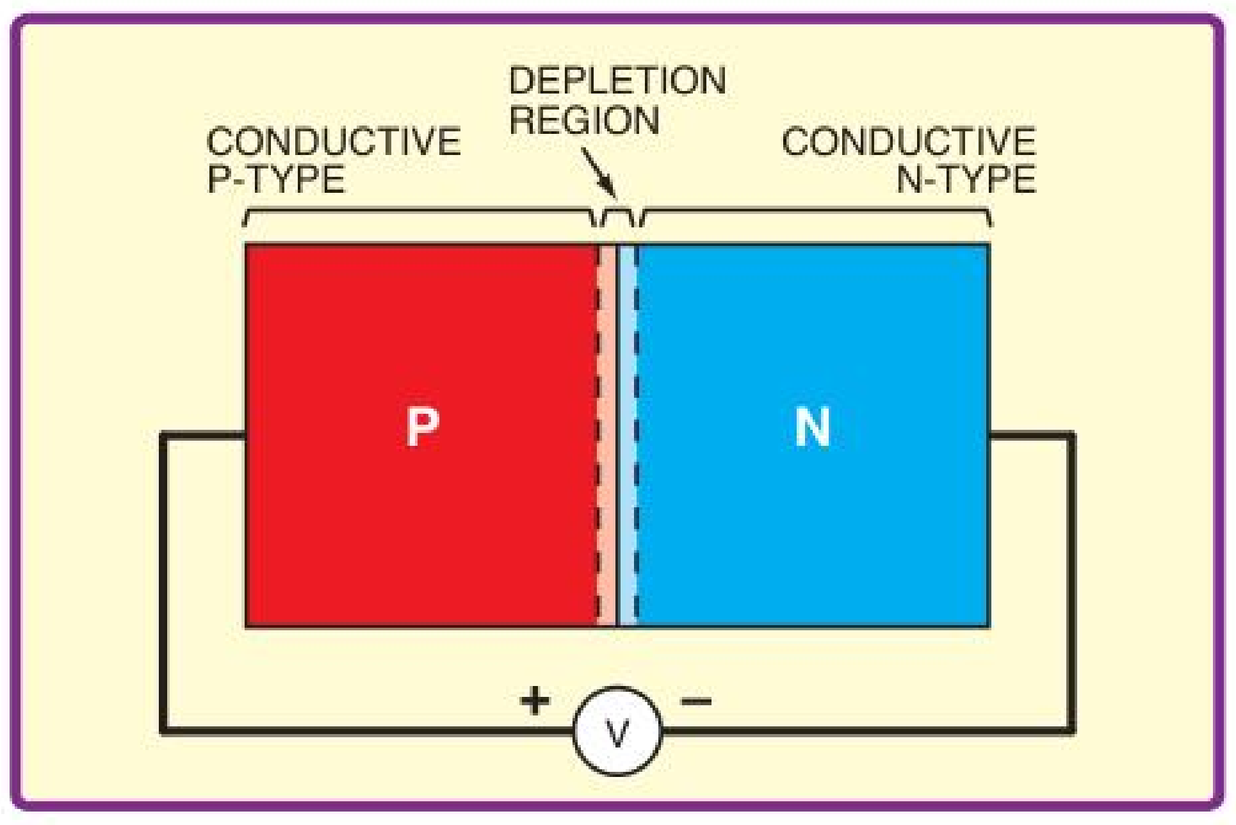

Fig.4. Forward biased PN *junction*

A bipolar junction transistor contains two *PN* junctions. This can be achieved using either a sequence *NPN* or *PNP* of doped layers in a single crystal of silicon (hence these names for the two transistor types). Like a diode, we make ohmic connections to each layer. The 'outer' layers (*N* for *NPN*, *P* for *PNP*) are the emitter and collector of the transistor. The middle region (*P* for *NPN*, *N* for *PNP*) is the transistor's base.

Now, in moving from emitter to collector (or *vice versa*) we go through two *PN* junctions in opposite directions. This is like two back-to-back diodes; but if this is all there was to a transistor there would never be any significant conduction from collector to emitter, because whatever way round we connected a collector-emitter voltage one of these junctions is reverse biased. The key to transistor operation is in the geometry and doping of the layers – the base region is very thin and relatively lightly doped – this ensures that the transistor does not behave just as two separate diodes.

A turn on

For transistor action we forward bias one of the *PN* junctions (the base-emitter junction) and apply sufficient voltage to turn on the base-emitter diode. We also reverse bias the base-collector junction. For example, for a *NPN* transistor we make the base positive with respect to the emitter and the collector positive with respect to the base, as shown in Fig.5 and correspondingly in Fig.1.

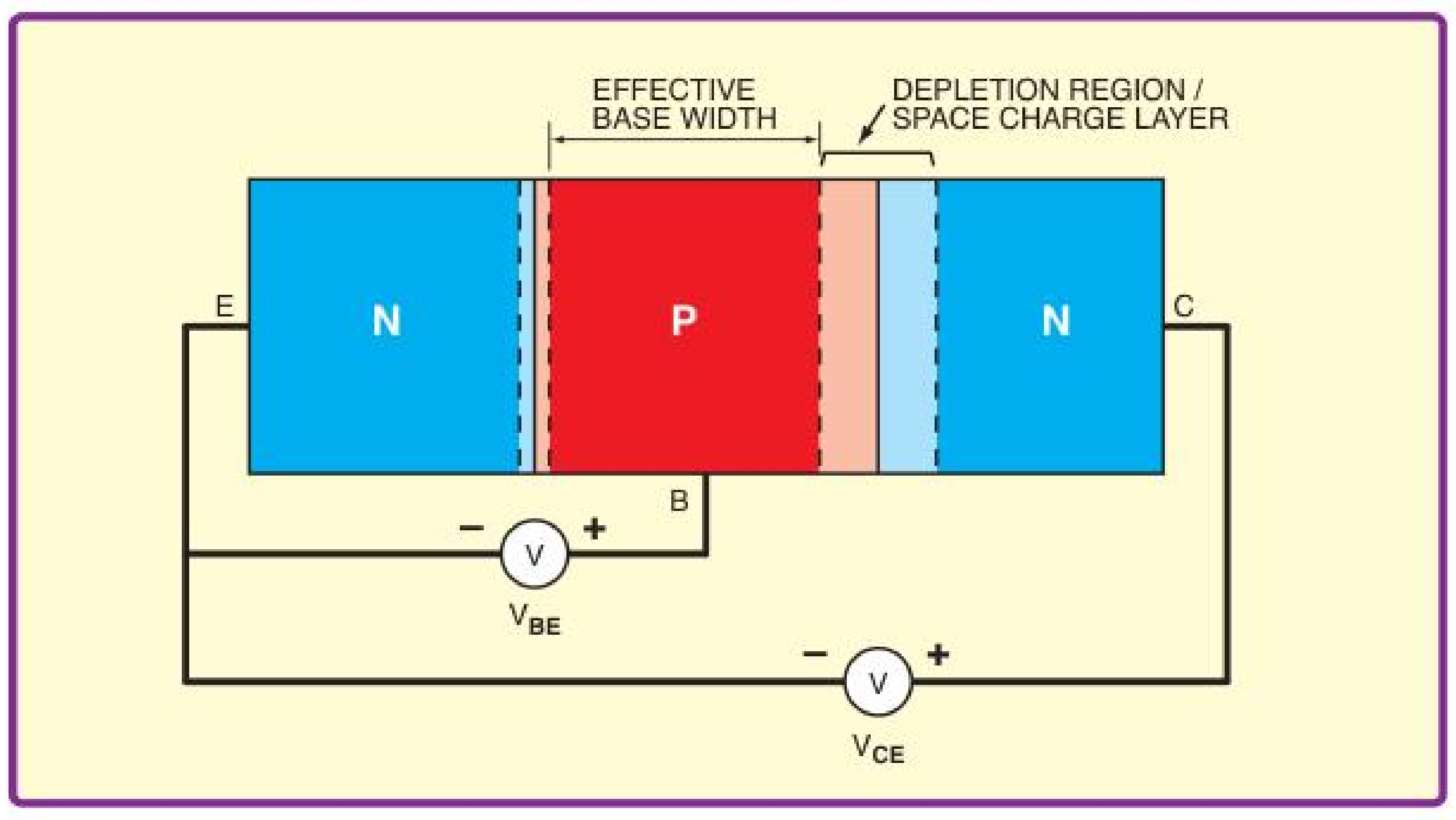

Fig.5. An NPN *transistor structure showing base-collector depletion region and effective base width*

Recalling that diode forward conduction produces minority carrier injection; in an *NPN* transistor conduction via the base-emitter junction will inject minority carrier electrons into the *P*-type base. Also recall that minority carriers can cross a reverse biased *PN* junction, thus the electrons entering the base of an *NPN* transistor can be swept across the base-collector junction by the attraction of a positive voltage on the collector.

Some of the electrons crossing the base region will recombine with holes. These holes will be replaced by more holes moving into the base (the base current). Because the collector is positive with respect to the base, the pull on the electrons to the collector is strong, and because the base region is very thin – so the electrons do not spend much time in the base to have chance to recombine – most of the injected electrons will end up in the collector.

Ideally, for fixed conditions at the base (base current) the amount of recombination would be constant and thus changing the collector voltage would not change the collector current, as long as the base-collector junction remained reverse biased. The transistor would behave as a current source (via the collector), with the current value controlled solely by the base. The output characteristics of such an ideal transistor are shown in Fig.6.

The graph in Fig.6a shows plots of collector current, I_C, against collector-emitter voltage, V_{CE}, for three different base currents. Once V_{CE} is above the low voltages which constitute the saturation region of operation, the collector current is constant for a given base current, that is, it is independent of V_{CE}. It is the active region we are interested in for this discussion.

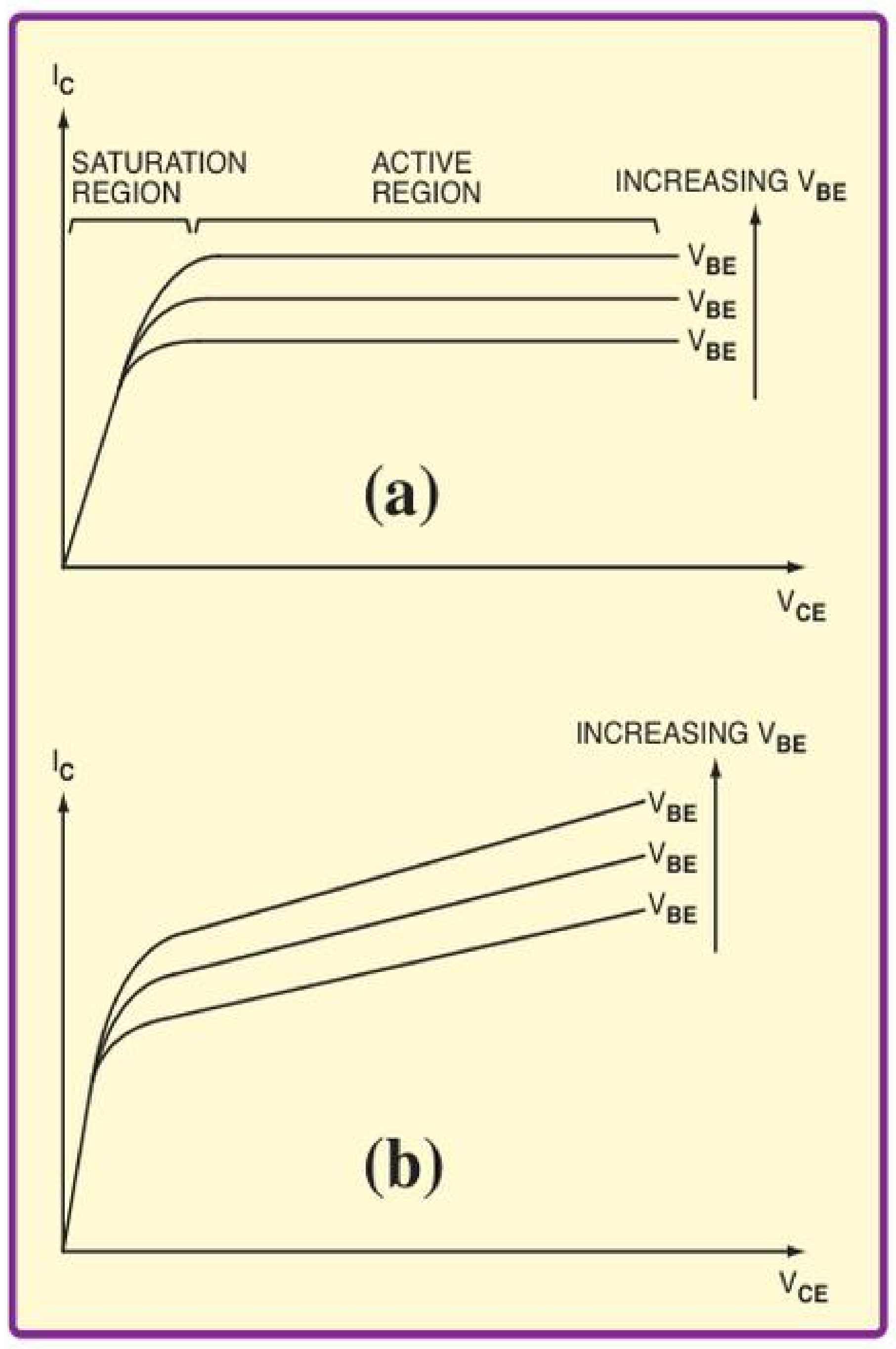

Fig.6. (a). Transistor common-emitter output characteristics for idealised transistor without Early effect, and (b) transistor common-emitter output characteristics including the Early effect, which causes the curves to slope rather than be flat in the active region (compare with Fig.6(a))

Base width modulation

In reality, things are not so straightforward. Recall that changing the reverse bias of a *PN* junction changes the size of the depletion region. This happens to the base-collector junction when the collector voltage is changed. Making the collector voltage more positive increases the size of the depletion region (or space charge layer if you prefer), which decreases the size of the conducting base region (see Fig.5). This is the Early effect.

The fact that changing the collector voltage changes the effective width of the base means that the Early effect is also (and now more commonly) referred to as 'base width modulation' as well as 'space-charge layer widening'.

The reduction in effective base width as collector voltage increases gives electrons moving across the base less time to recombine, so a smaller proportion will do so. Thus, as the collector voltage is increased at a fixed base current, collector current will also increase. This results in the output characteristics shown in Fig.7 where the curves can be seen to slope up in the active region. The slope of the curve (change in I_C divided by change in V_{CE}) is the output conductance (h_{oe}) of the transistor at that base current.

Looking at Fig.6 in detail you may notice that the slope of the curves increases as base current increases. If we extrapolate the straight line sections of all the I_C curves for different base currents they converge at more or less the same point on the V_{CE} axis, as shown in Fig.7. This point represents a voltage which is characteristic of the particular transistor. The voltage on the axis is negative at this point, but the positive voltage of same value is referred to as the Early voltage (symbol V_A) because it indicates the strength of the Early effect on output conductance (or resistance) for that transistor. Typical values are 50V to 100V.

This month, we have explored the physical process in the transistor which lead to the Early effect, and have shown how Early voltage is usually defined. Next month, we will look at its impact on circuit performance and how we approach analysing this in circuit design through parameters such as h_{oe} and h_{re}.

Reference

Early, JM, Effects of Space-Charge Layer Widening in Junction Transistors, *Proceedings of the IRE*, vol.40, no.11, pp.1401-1406, Nov. 1952.

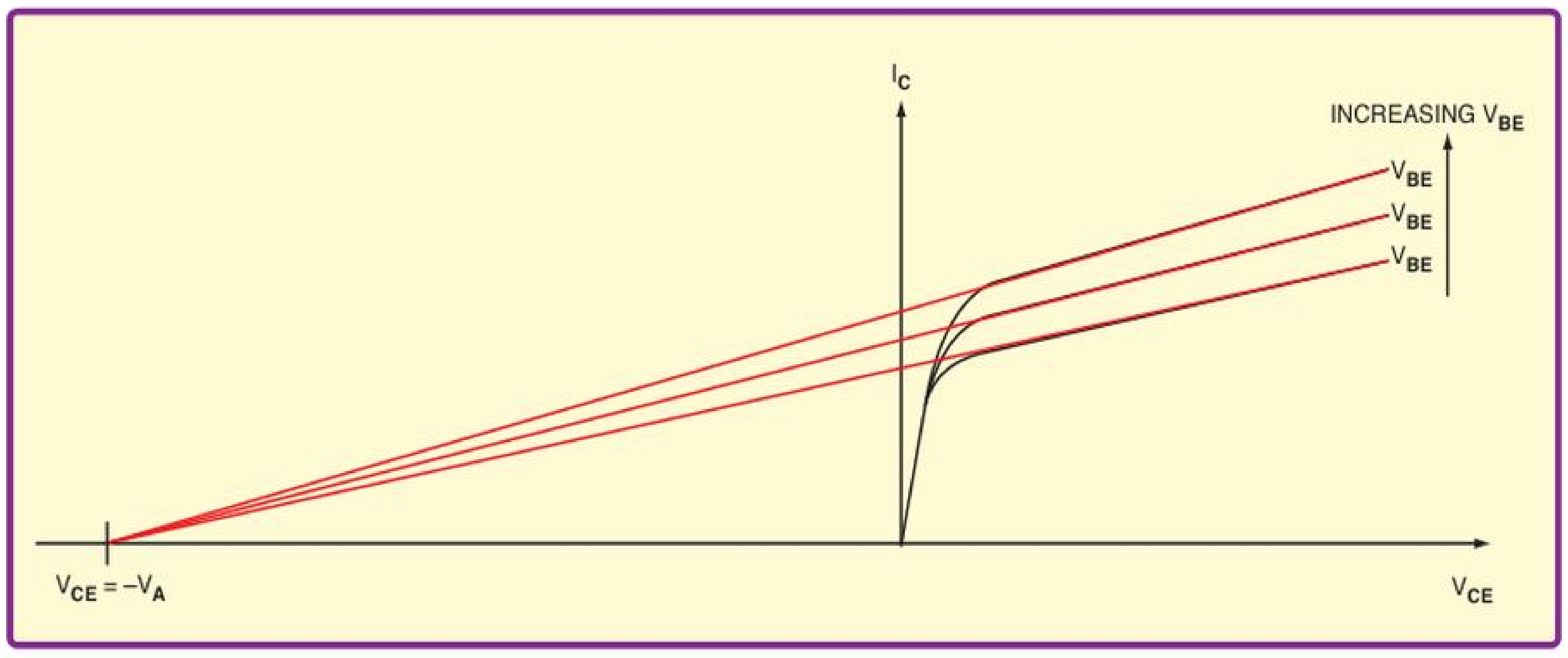

Fig.7. Finding the Early voltage from the transistor output characteristics

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Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

Made to measure!

GETTING to terms with the units of measurement used in electronics is one of the first obstacles that newcomers to the hobby have to overcome. We are all familiar with metres, grams, and degrees Celsius, but prior to an interest in electronics you will probably not have encountered farads, ohms, or henries.

Matters are complicated by the fact that a broad range of values are often used. The largest capacitors in normal use for example, have values that are more than a billion times bigger than those of the smallest types. It is further complicated by the fact that, by normal electronic standards anyway, some of the basic units are very large or incredibly small. You could be using a ten-million-ohm resistor one minute and a one billionth of a farad capacitor the next.

Up front

The prefixes used for electronic values follow the standard metric system. A kilometre is a thousand metres, and a kilohm is a thousand ohms. Table 1 shows the prefixes that are likely to be encountered in electronics, together with the single letter abbreviation used for each one.

It should be noted that the case is important with these abbreviations, and that 'M' for example means a million, whereas 'm' means a thousandth. The single letter abbreviation for micro is the Greek letter mu (μ), but 'u' is often used instead.

Table 1

Multiply/Divide	Prefix	Letter
x1000000000	giga	G
x1000000	meg/mega	M
x1000	kilo	k
/1000	milli	m
/1000000	micro	μ or u
/1000000000	nano	n
/1000000000000	pico	p

Resistance

The basic measurement of resistance is the ohm. An ohm is a fairly small basic unit, and resistors are commonly available with values from about 1 ohm to 10 million ohms. However, the higher power types with ratings of a few watts or more have relatively low values, typically starting at 0.1 ohms and going up to a few hundred ohms. There are special high value components having resistances of 100 million ohms or more, but they are little used in real-world electronic circuits. They require special handling precautions in order to avoid impairing their accuracy.

The Greek letter omega (Ω) is used to indicate that a value is in ohms. Therefore a 470Ω resistor has a value of 470 ohms. The letter 'R' is often used in place of omega, and a value of 330 ohms might, therefore, appear on a circuit as either '330Ω' or '330R', or possibly even as just '330'. It is now standard practice for the character denoting the unit of measurement to indicate the position of the decimal point as well. A 3.9 ohm resistor for instance, would normally have its value given in the form '3Ω9' or '3R9'.

The basic ohm is fine when dealing with resistors of several hundred ohms or less, but many everyday resistors have values of thousands or even millions of ohms. Kilohms and megohms are therefore used for higher value components. The abbreviation for kilohm is 'kΩ' or just 'k', and the abbreviation for megohm is 'MΩ' or just 'M'. As with lower values, the letter indicating the unit of measurement is normally used to show the position of the decimal point as well. A value of 5.6 kilohms would normally be given in the form '5k6', and a value of 6.8 megohms would be given as '6M8'.

Colour conscious

Some resistors have the value written on their body, usually together with a tolerance rating or code letter, but this method is mainly restricted to high power resistors. Colour coding is normally used to mark the value and tolerance rating of resistors having a power rating of less than about one watt. There is more than one version of resistor colour coding, but the four band version is the most common type. This uses the method of coding shown in Fig.1. Table 2 shows the meaning of each colour for each of the bands.

It used to be the norm for band 4 to be well separated from the other three bands, but these days there is often no discernible difference in the spacing. Getting bands 1 and 4 confused and reading the colours backwards should not be a problem though. Band 1 is much nearer to its end of the body, and may well be right at one end of the body. The small resistors used in most projects have a tolerance rating of 5%, which is represented by a gold band. This helps to avoid any confusion, since gold is never used in bands 1 or 2.

As an example of a resistor code, suppose that the bands are green, blue, yellow, and gold. Bands 1 and 2 provide the first two digits of the value, which in this case are green (5) and blue (6). The first two digits of the value are therefore '56'. The third band provides the multiplier, and in

Table 2

Colour	Band1/2	Band 3	Band 4
Black	0	x1	-
Brown	1	x10	1%
Red	2	x100	2%
Orange	3	x1000	-
Yellow	4	x10000	-
Green	5	x100000	0.5%
Blue	6	x1000000	0.25%
Violet	7	-	0.1%
Grey	8	-	-
White	9	-	-
Gold	-	0.1	5%
Silver	-	0.01	10%
None	-	-	20%

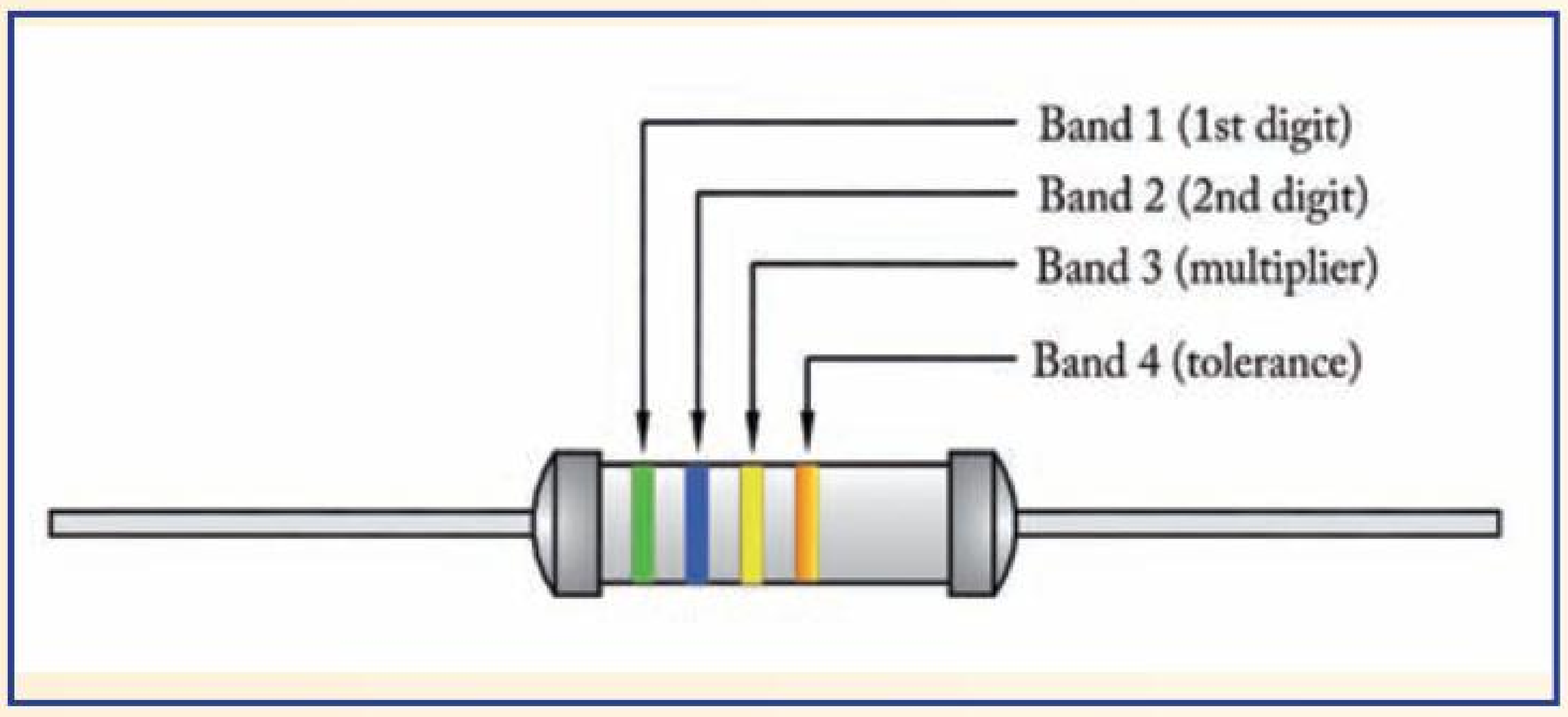


Fig.1. The standard four band method of resistor colour coding. In this example, the component has a value of 560 kilohms (560kΩ) and a tolerance rating of 5%

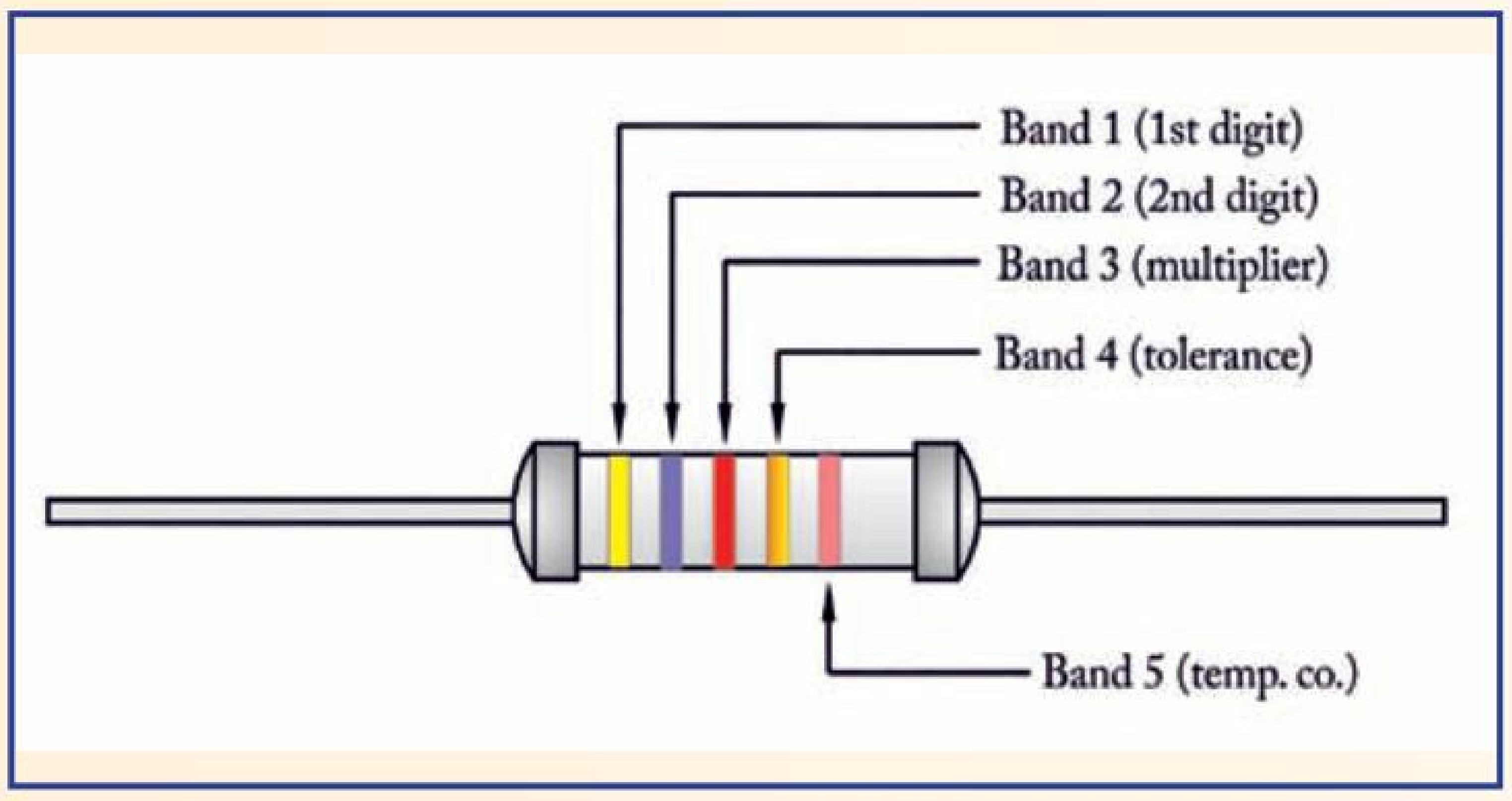


Fig.2. This five band method of coding is essentially the same as the four band type. Ignore the fifth band and read the value in the normal way (4.7 kilohms in this example)

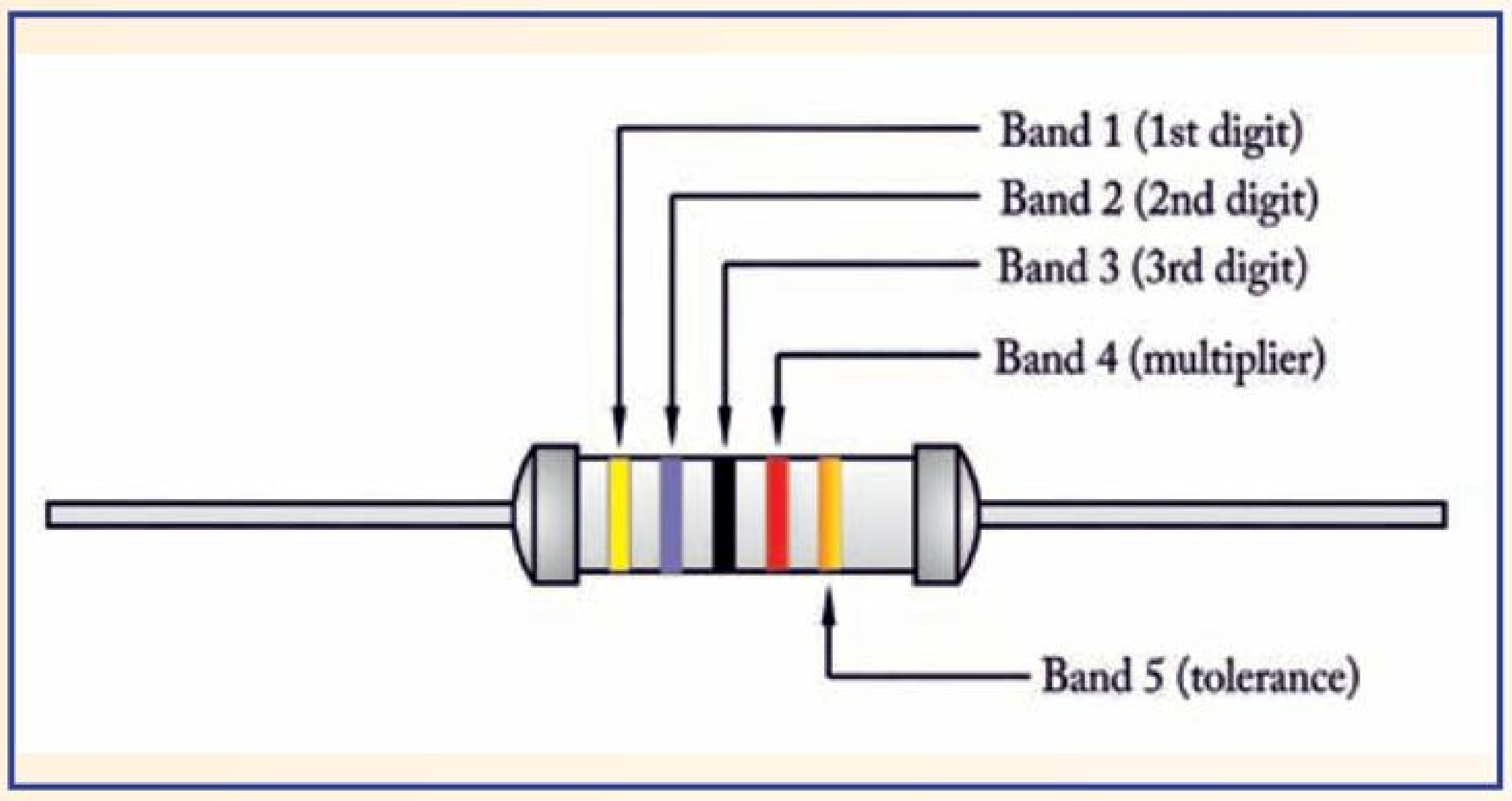


Fig.3. An alternative form of five band colour coding. With preferred values the third band is always black

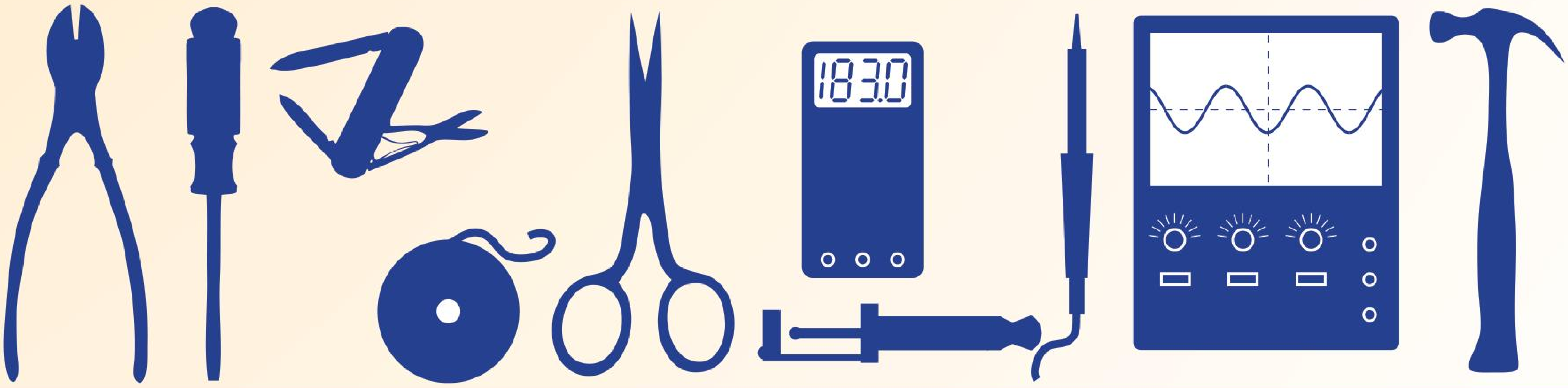
this example it is yellow (×10000). This produces a final value of 56 × 10000, or 560000 ohms (560kΩ). The fourth band is gold, indicating that the marked value has a tolerance of plus or minus 5%. In other words, the actual value is somewhere between 532 and 588kΩ.

Of course, it is acceptable to use a component that has a better tolerance than the one specified in the components list. A 1% or 2% component could be used instead of a 5% type for example, but a 5% component should not be used in place of a 1% or 2% type. Similarly, from the electrical point of view, a resistor having a higher power rating than the one specified is perfectly acceptable. Bear in mind though, that a higher power rating is normally accompanied by an increase in physical size. A component having a higher power rating might not fit into the available space on the circuit board.

Resistor colour coding is complicated slightly by two five band versions of the code. With one type the extra band only indicates the temperature coefficient of the component. This is usually of no consequence, and the fifth band can be ignored. Just use the first four bands to provide the value in the normal way. In the example of Fig.2, the value is therefore 4.7kΩ. The other five band method of coding is a little more difficult to deal with. It uses the first three bands to indicate the first three digits of the value. Bands 4 and 5 then provide the multiplier and tolerance rating in the normal way (Fig.3).

Resistors, capacitors and inductors are generally only available in a standard range of values, or ‘preferred’ values as they are known. These values can be handled by the four band method of coding. Having three bands for the initial digits enables non-standard values to be accommodated, which is probably of no practical importance to electronic project builders. For preferred values, the third band is always black (0). It is therefore possible to calculate the value in the normal way, but with the third band being ignored. However, the figure obtained must then be multiplied by ten in order to compensate for the ignored zero, and give the final value. As an example, suppose the four bands used to provide an initial figure produce an answer of 4.7kΩ. The actual value of the resistor is 47kΩ.

I know from personal experience that having a stock of resistors that consists of a mixture of four and five-band components tends to cause confusion and errors. This is especially the case if you end up having to deal with both types of five band coding as well as the standard four band type. If at all possible, it is best to avoid resistors



that use this second form of five band coding.

There is actually a six band code, which is likely to be encountered rarely if ever. It has the extra digit band and the temperature coefficient one. The value can therefore be read as per the second type of five band code, with the sixth band being ignored

Capacitors

Although using colour coding might seem to be doing things the hard way, it does have advantages. On tiny components it avoids having to use minute lettering that could only be read with the aid of a magnifier. Small bands or spots of colour are generally much easier to read. The markings on a colour coded component have to be quite severely damaged in order to render them unreadable, but with letters and figures it often requires minimal damage in order to make the markings ambiguous or misleading.

Colour coding was once common for various types of capacitor, but despite the potential advantages it no longer seems to be used with any capacitors. If you should encounter a colour coded component, it should not be too difficult to decipher its value. The systems of coding used for capacitors are mostly based on the resistor type, and the first three colours give the value in picofarads (pF).

The values are simply written on modern capacitors, but are not necessarily in an obvious and easily understood form. Ceramic capacitors often have a marking such as 'n47'. Here the letter is being used to denote the units in use (nanofarads) and the position of the decimal point, and the leading zero is omitted. The value is therefore 0.47 nanofarads, in other words 470 picofarads. By no means do all small ceramic capacitors have this method of indicating the value, which in this example is just as likely to be marked as '470p' or even just '470'.

Another slightly confusing method is to have the value in the form of a three digit number. The first two digits of the label are simply the first two digits of the value. The third digit indicates the number of zeros that have to be added to the basic value, and it performs the same task as the multiplier band in a resistor colour code. As an example, a capacitor marked '273' has '27' as the first two digits of the value, and three zeros must be added to these in order to provide the full value. This gives an answer of 27000. The value is in picofarads, and in this example it is therefore 27000 picofarads, or 27 nanofarads.

There is a potential source of confusion with this system, where a value of (say) 47 picofarads would be marked as '470' (47 plus no zeros added). Unless you know that this method of marking is in use you could be forgiven for thinking that the value was 470 picofarads.

To the letter

There are often other markings present on capacitors, and some of these will probably just be the usual batch numbers and so on. Others show such things as the tolerance and maximum voltage rating.

The tolerance is often indicated by a single letter and a simple method of coding, so you have to be careful to avoid interpreting a tolerance code letter as part of the value. Table 3 shows the tolerance ratings for the commonly encountered code letters:

Table 3

Code Letter	Tolerance
F	+/- 1%
G	+/- 2%
H	+/- 3%
J	+/- 5%
K	+/- 10%
M	+/- 20%

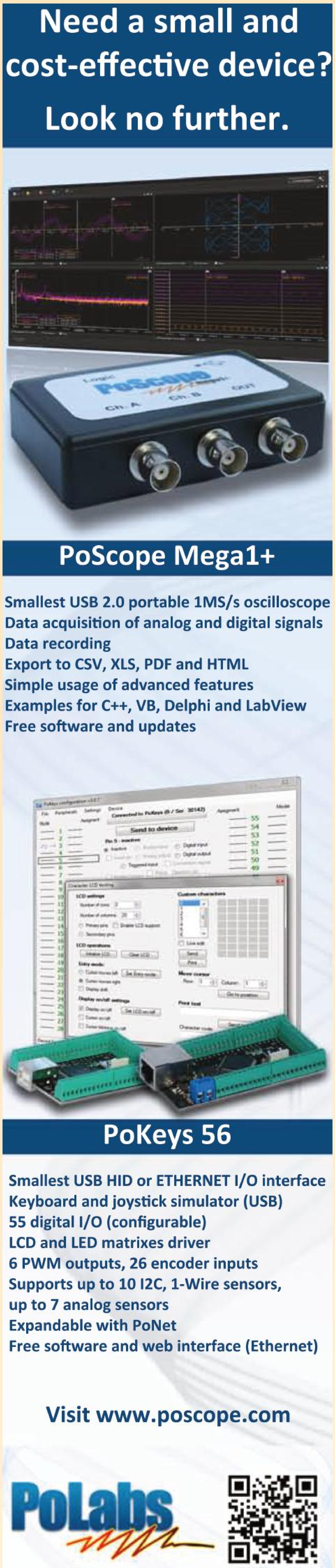
Inductors

Inductors, which are also known as chokes, are not used in electronic projects to anything like the same extent as resistors and capacitors. In fact, they are something of a rarity by comparison.

The basic unit of inductance is the henry, which is an enormous amount of inductance. Consequently, most real-world inductors have their values expressed in millihenries, microhenries or nanohenries. These are respectively millionths, thousandths, and billionths of a henry.

With large inductors, the value is normally written on the body of the component, and other parameters might be included, such as the tolerance and a maximum operating current. The same method is used for many small inductors, but some have the value marked using a system of colour coding. This operates in essentially the same manner as standard four-band resistor colour coding, but the value is in nanohenries rather than ohms. Dividing the figure obtained by one thousand or one million respectively gives an answer in microhenries or millihenries.

For instance, suppose an inductor is colour coded red, violet, red, and gold. The first three colours provide the basic value, which in this case is 2700 (27 × 100) and is in nanohenries. Dividing this by one thousand gives a value of 2.7 microhenries. The fourth band, which is gold in this example, indicates the tolerance in the usual way. The tolerance rating of the component is therefore plus or minus five percent.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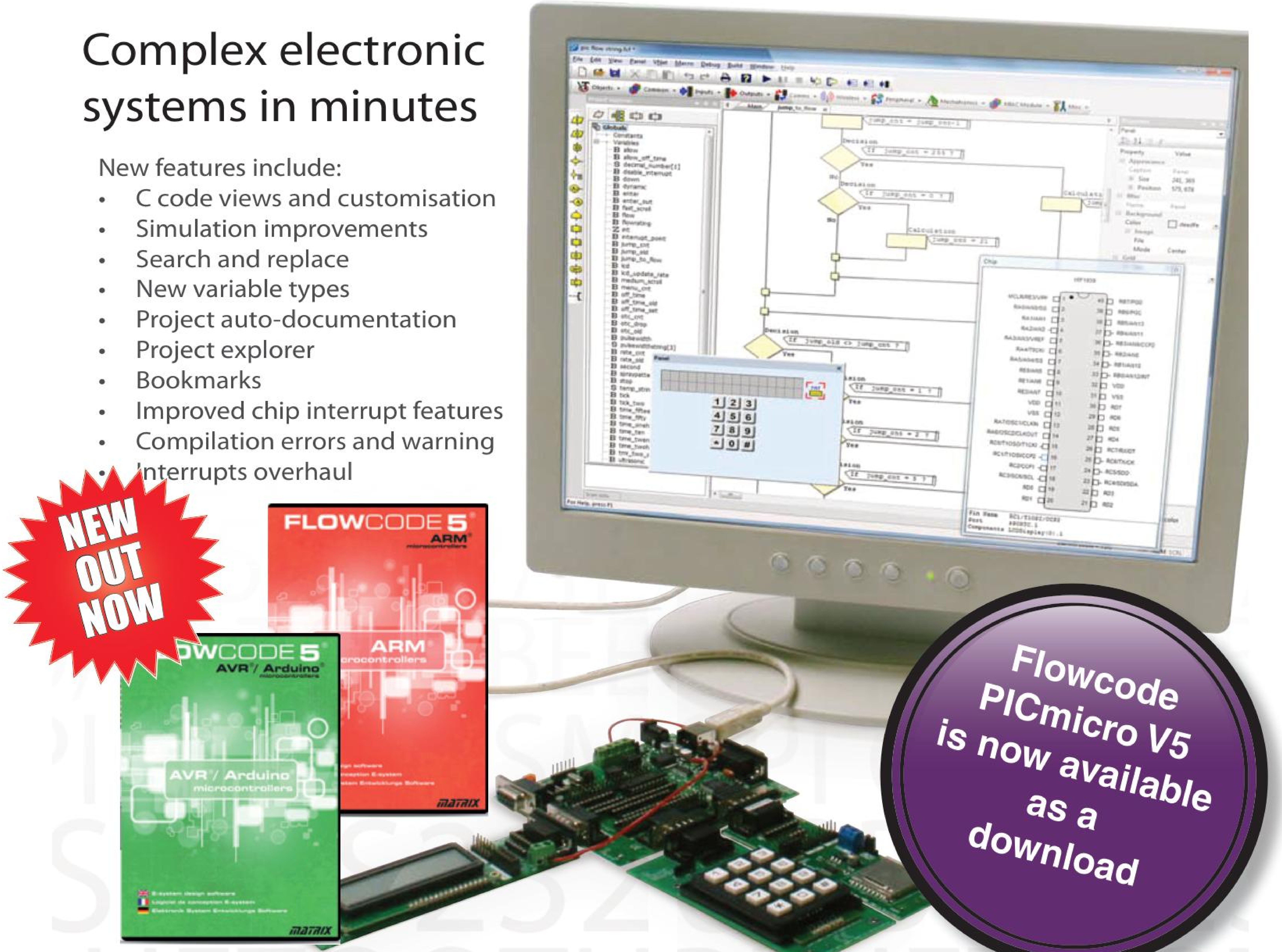
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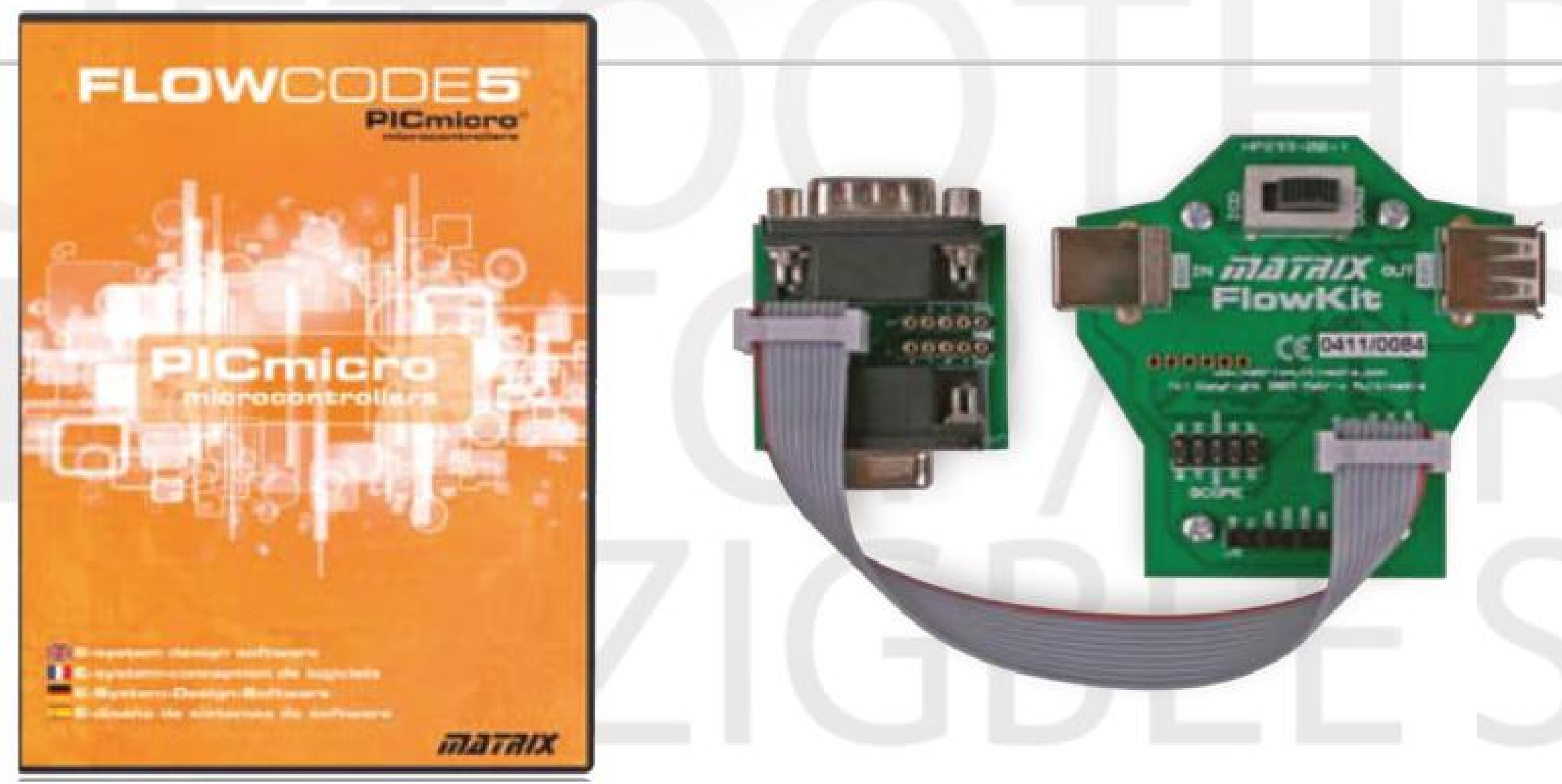
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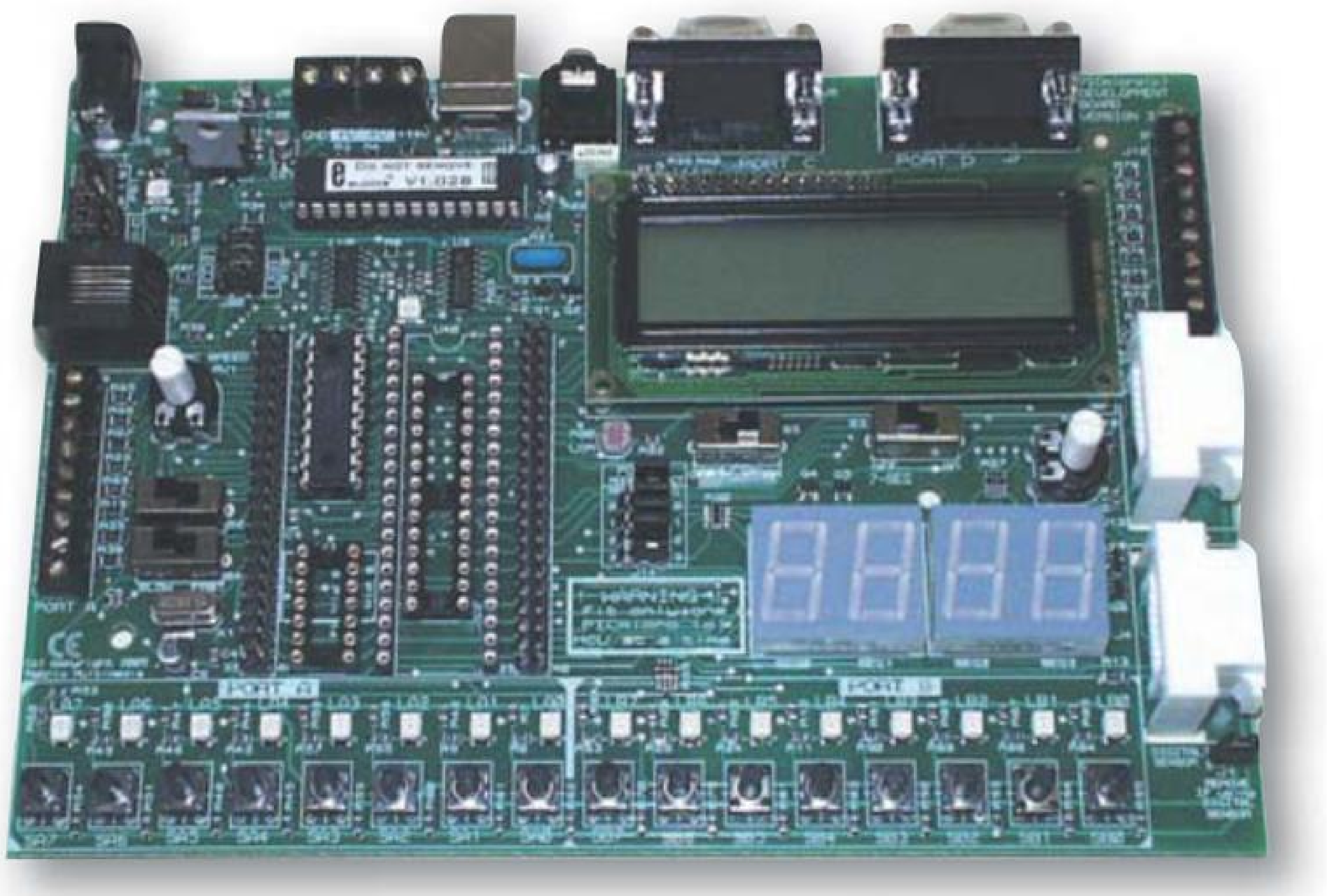
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- USB programmable
- Can be powered by USB (no power supply required)



£161 including VAT and postage, supplied with USB cable and programming software

SOFTWARE

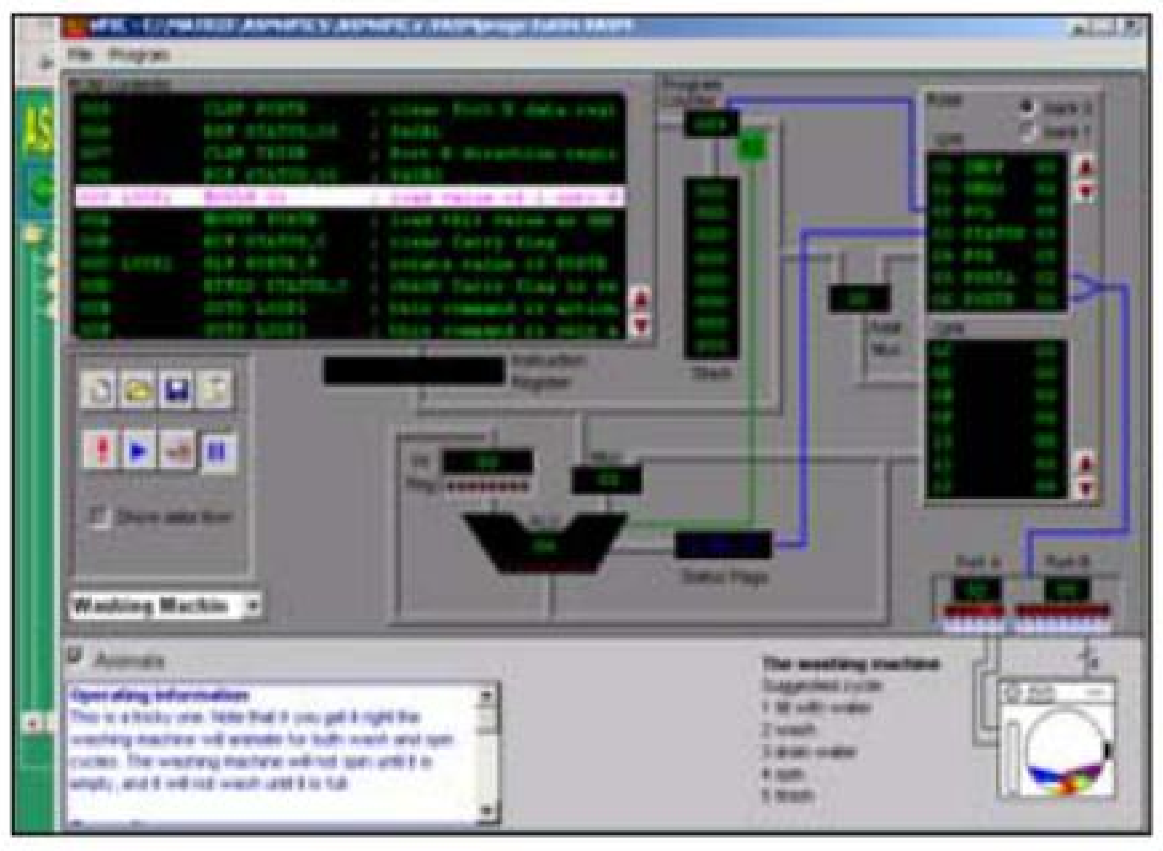
ASSEMBLY FOR PICmicro V4

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller, this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed, which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

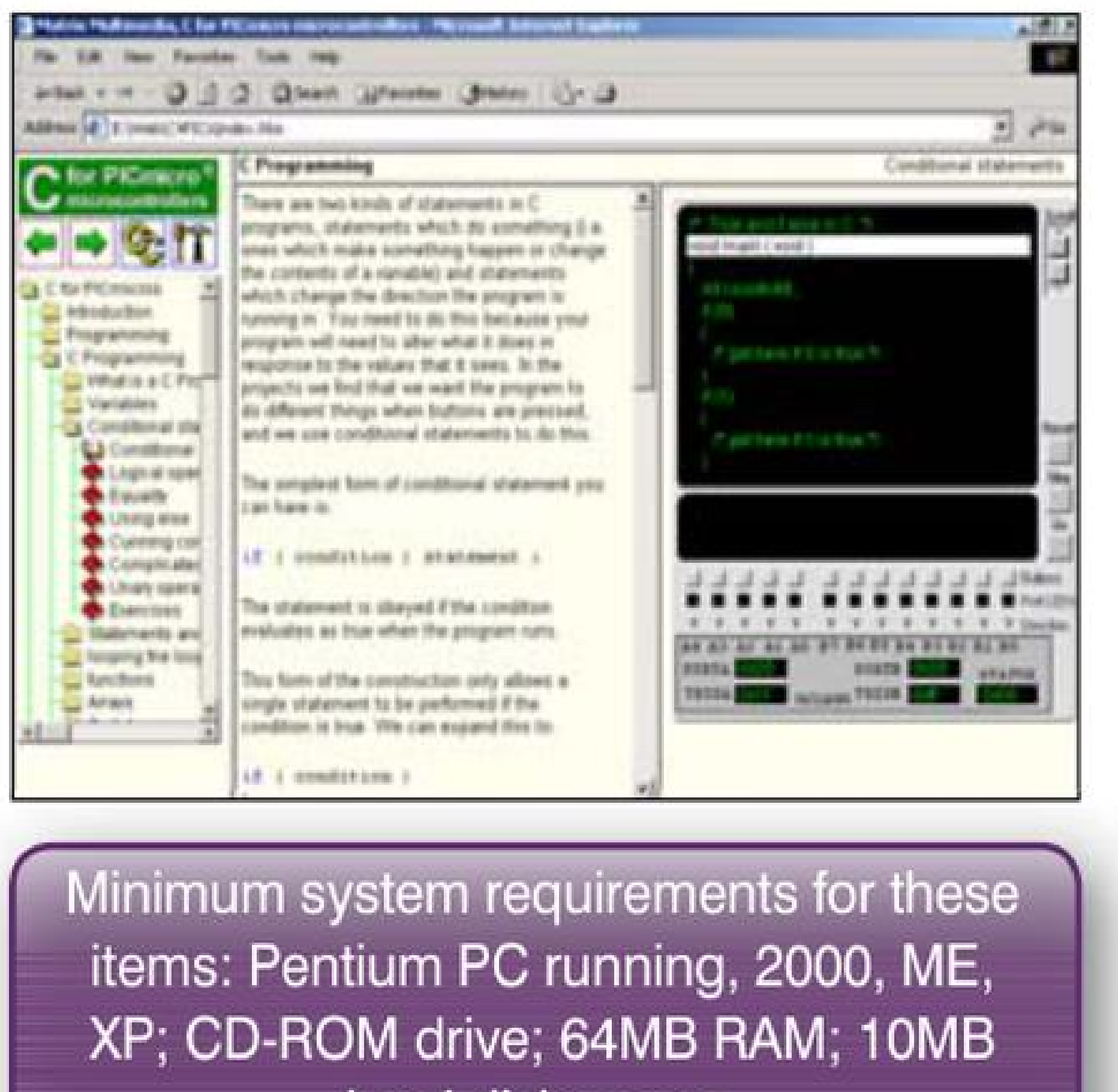


‘C’ FOR 16 Series PICmicro Version 4

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD-ROM contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



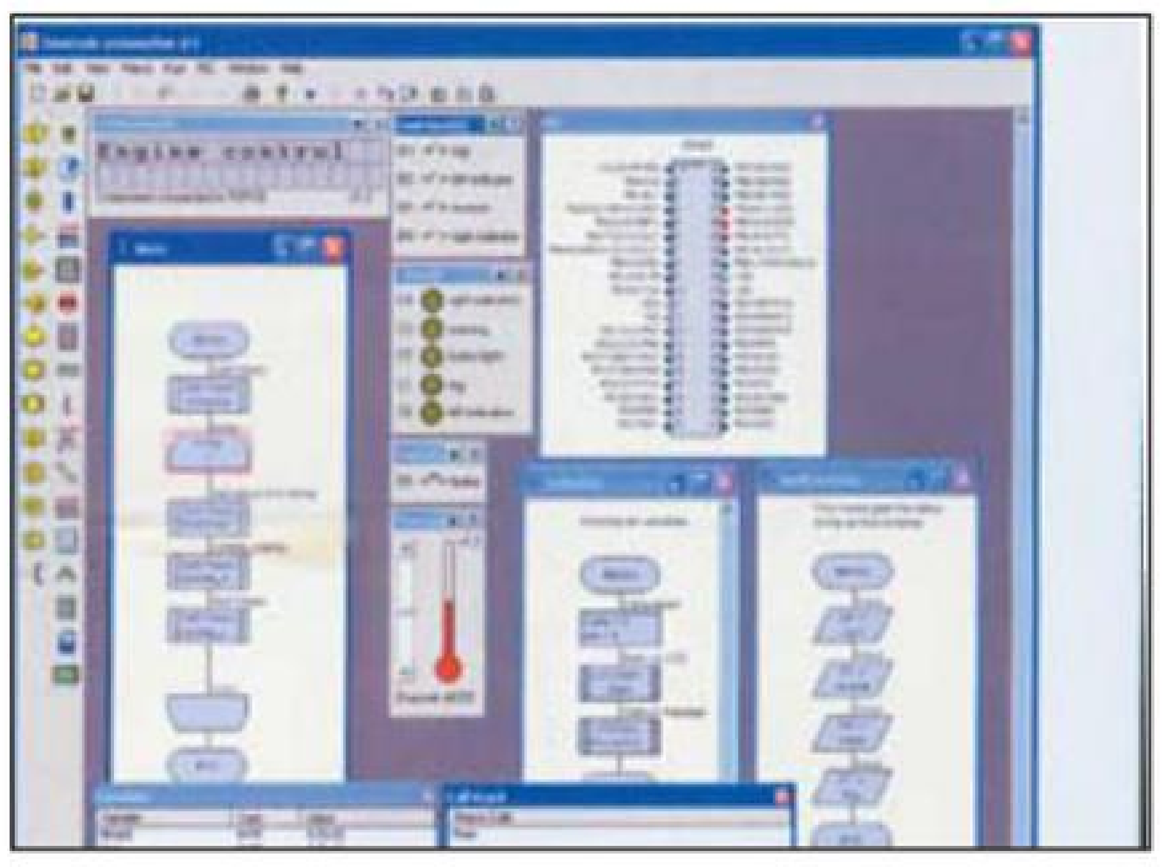
Minimum system requirements for these items: Pentium PC running, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.
Flowcode will run on XP or later operating systems

FLOWCODE FOR PICmicro V5 (see opposite page)

Flowcode is a very high level language programming system based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and LCDs. The use of macros allows you to control these devices without getting bogged down in understanding the programming. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

- Requires no programming experience
- Allows complex PICmicro applications to be designed quickly
- Uses international standard flow chart symbols
- Full on-screen simulation allows debugging and speeds up the development process.
- Facilitates learning via a full suite of demonstration tutorials
- Produces ASM code for a range of 18, 28 and 40-pin devices
- 16-bit arithmetic strings and string manipulation
- Pulse width modulation
- I2C.

Features include panel creator, in circuit debug, virtual networks, C code customisation, floating point and new components. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

(UK and EU customers add VAT to ‘plus VAT’ prices)

Hobbyist/Student	**£58.80**	**inc VAT**
Professional (Schools/HE/FE/Industry)	**£150**	**plus VAT**
Professional 10 user (Network Licence)	**£499**	**plus VAT**
Site Licence	**£999**	**plus VAT**
Flowcode Professional (Schools/HE/FE/Industry)	**£199**	**plus VAT**
Flowcode 10 user (Network Licence)	**£599**	**plus VAT**
Flowcode Site Licence	**£999**	**plus VAT**

CIRCUIT WIZARD

Circuit Wizard is a revolutionary new software system that combines circuit design, PCB design, simulation and CAD/CAM manufacture in one complete package.
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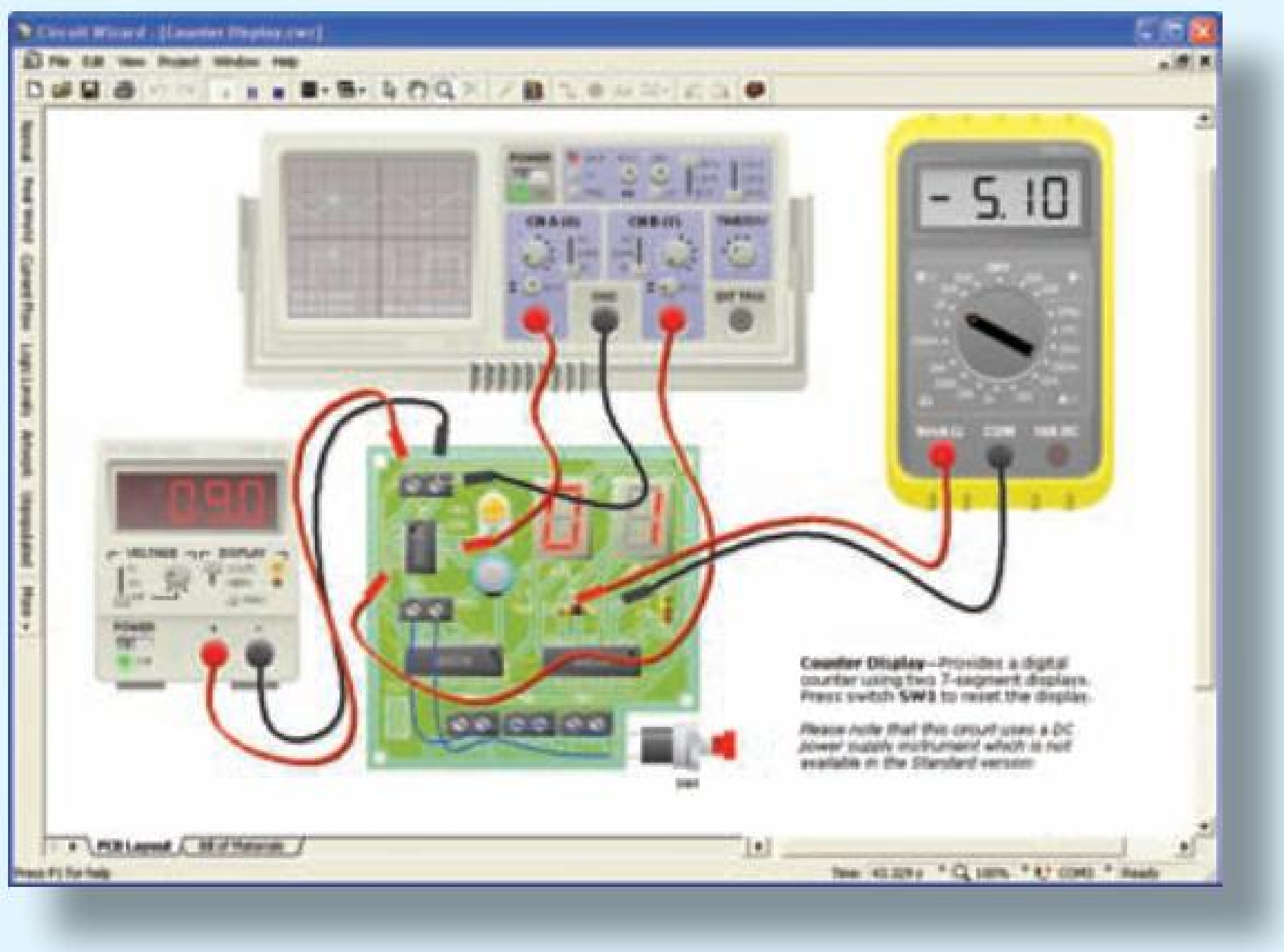

This software can be used with the *Jump Start* and *Teach-In 2011* series (and the *Teach-In 4* book).

Standard **£61.25** inc. VAT
Professional **£91.90** inc. VAT

Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 2000/ME/XP, mouse, sound card, web browser.

Please send me: CD-ROM ORDER FORM

☐ **Assembly for PICmicro V4**
☐ **'C' for 16 Series PICmicro V4**
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Version required:
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☐ **Professional 10 user**
☐ **Professional + Flowkit**
☐ **Site licence**

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☐ **Flowcode for dsPIC & PIC24 V4**

Note: The software on each version is the same, only the licence for use varies.

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EPE PIC RESOURCES V2

Version 2 includes the EPE PIC Tutorial V2 series of Supplements (EPE April, May, June 2003)

The CD-ROM contains the following Tutorial-related software and texts:

- EPE PIC Tutorial V2 complete series of articles plus demonstration software, John Becker, April, May, June '03
- PIC Toolkit Mk3 (TK3 hardware construction details), John Becker, Oct '01
- PIC Toolkit TK3 for Windows (software details), John Becker, Nov '01

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NET WORK

by Alan Winstanley

Time for FTP

LAST month, I mentioned how my Windows upgrade earlier this year had proceeded more or less to plan, with an older PC now running Windows 7 Professional without too much of a hitch. Many answers to Windows upgrade problems can be found online and I particularly commend to readers the dedicated W7 site at: **www.sevenforums.com**.

The bloat of Internet Explorer 9 sometimes makes my system groan a bit, and Firefox is an altogether slicker web browser for legacy systems. I use both browsers routinely, but choose Firefox for more intensive surfing sessions. Firefox has a range of useful third-party plug-ins and extensions to make life easier (see them all at **https://addons.mozilla.org/**), but it has a habit of upgrading itself every month; a few moments ago I noticed how I'm now running Firefox 15.0, a two version hop in just two months.

Windows 7 also introduced widgets or 'gadgets' – small desktop applets that stream information to the user visually. Microsoft soon got bored with the idea though and only a spartan choice of standard gadgets is still available, including network activity, a useful CPU resources meter, a clock and weather forecast gadget. Microsoft cautions against downloading gadgets from untrusted third parties: could it possibly be because of the security risks that downloads pose?

Most of my legacy programs run fine under Windows 7 and most problems were gradually overcome. One disappointment has been the popular FTP program WS_FTP Pro by Ipswitch: an expensive upgrade to V12.3 was needed just for W7 compatibility, but I found that whenever the iconbar was dragged, the software crashed. Technical Support agreed: that's funny, ours does the same. Such a blatant bug is unacceptable and WS_FTP Pro is one of only two PC programs (the other being Quicken 2000) that I ever rejected. It reminded me to not to take new software for granted, but to test programs as thoroughly as possible during the initial trial period.

In our web-obsessed world, File Transfer Protocol (FTP) software is overlooked, but it still has its uses. For example, unlike the use of a web-based system (http) for uploading files, traditional FTP can be a better way of uploading many megabytes' worth of photographs to a stock image website, as FTP can be more robust, offer more control and provide a full log of transfers. Readers could try WS_FTP LE, their recently re-introduced and soft-launched free 'lite' edition available on an annual licence from **www.wsftple.com**. A popular free alternative is Filezilla from **http://filezilla-project.org**.

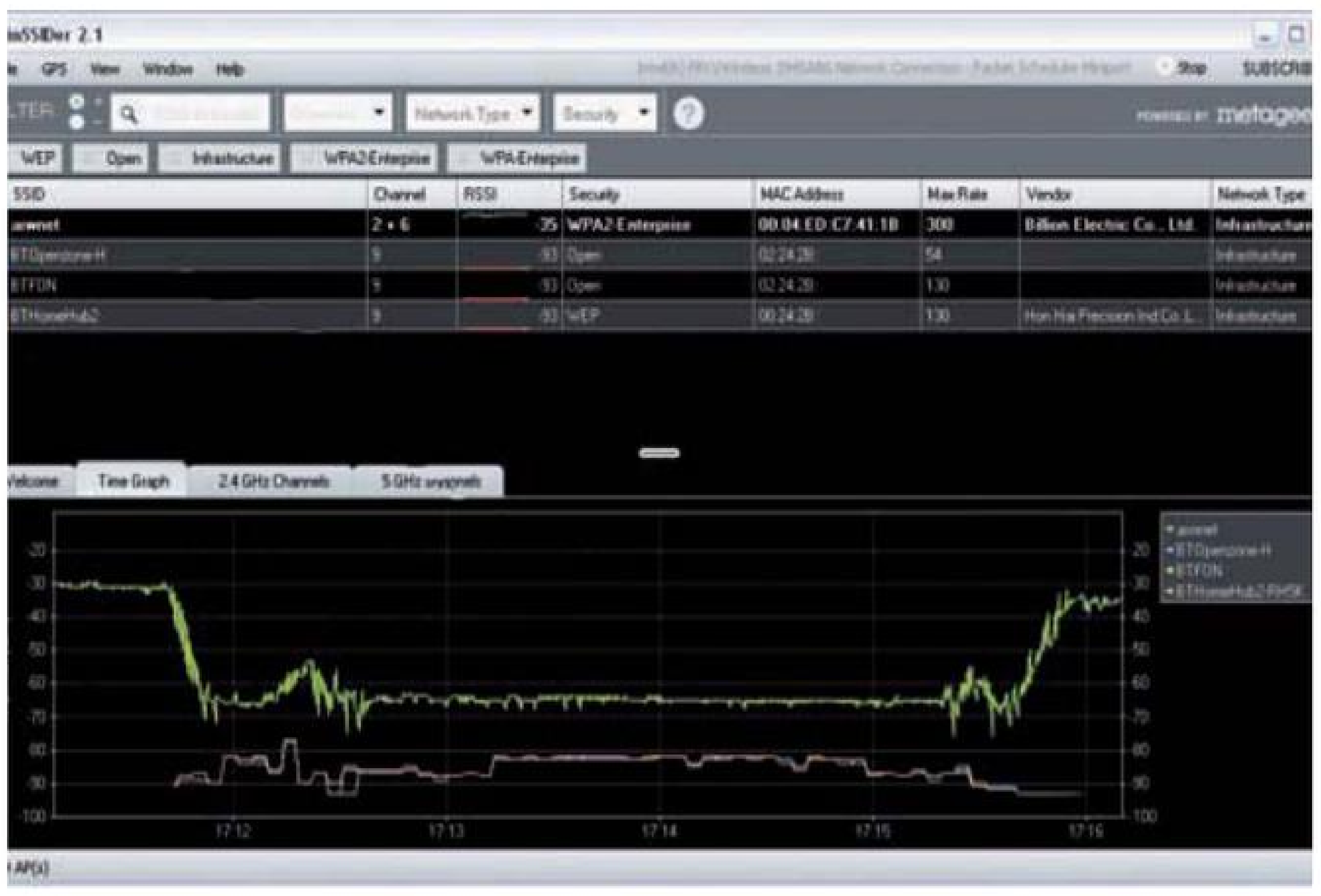
By the time you read this, Windows 8 will have appeared on the market. It could be pre-ordered in September and the rush is on to offer Windows 8-compatible products, together with patches, drivers and upgrades. Manufacturers will continue to push the latest hardware and software relentlessly, but many of us will be satisfied with Windows 7 or even XP. Keeping one eye on the medium term, Windows 7 will be perfectly fine for years to come yet. Note that official support for Windows XP expires on 8 April 2014 when Microsoft stops pushing out security updates or patches for its 13-year-old OS. A Doomsday countdown timer on Microsoft's website serves as a reminder.

Fried chips

At this point, readers, I can reveal that not everything went entirely to plan with my reconstructed Windows 7 system. Halfway through an intensive work session one day, my screen suddenly froze and the PC emitted a horrid screeching sound. My heart sank as the motherboard's speech-enabled debugger opined that 'Your memory may have a problem' (itself true). I feared the system's new hard disk could have crashed, spelling several days of outage, lost revenue and onerous data restoration.

Opening the case of my self-built PC revealed the cause: the motherboard's Northbridge heatsink was hanging off the board and dangling in mid air! The retaining clip had come away from the board and I feared the Intel chip underneath it might have fried. I thought it was worth trying a repair, or Plan B would be to drop in the spare motherboard I sourced years ago from eBay. So, with fingers, crossed the retaining clip was resoldered and a morsel of silicone grease applied to the heatsink, which was re-assembled: happily the system rebooted successfully and work resumed once again. Phew, that was a close shave!

This alarming incident was a timely reminder that a hardware failure, whether PC or a Mac, can happen without warning and may not be restricted to a simple hard disk or memory chip failure. In previous columns, I've outlined various strategies for backing up essential data online, in addition to which I have a rigorous and tested routine based on the excellent Reflect 5 backup software from Paramount Software UK Ltd, which backs up on to my RAID-style NAS. Reflect is downloadable from: **www.macrium.com**. In slow-time, I will document my serial numbers and save them online too. Many program serial numbers can often be recovered from a system using Magic JellyBean Keyfinder, free from: **www.magicaljellybean.com/keyfinder**.



SSID	Channel	RSSI	Security	MAC Address	Max Rate	Vendor	Network Type
awnet	2 + 6	-35	WPA2-Enterprise	00:04:ED:C7:41:1B	300	Billion Electric Co., Ltd.	Infrastructure
BTOpenzone-H	9	-93	Open	02:24:28	54		Infrastructure
BTFON	9	-93	Open	02:24:28	130		Infrastructure
BTHomeHub2	9	-93	WEP	00:24:28	130	Hon Hai Precision Ind.Co.L...	Infrastructure

inSSIDer shows the received signal strength indication (RSSI) of Wi-Fi networks detected on a laptop. The author's router's signal (green trace) falls as the laptop moves around the building. Neighbouring BT Home Hub networks are also detected

Coming into range

One aspect of Internet networking that causes much muttering is that of Wi-Fi coverage and reliability. Despite using a good quality Billions 7800N SoHo router that I've praised in previous columns, wireless access indoors is still occasionally erratic. In order to pinpoint the likely cause I downloaded inSSIDer free from Metageek.net. This open-source program (Windows, Mac and Android) enables Wi-Fi users to examine what's going on around them, detecting the presence of neighbouring networks, their signal strengths and the possibility of overlapping channels. In my case, I suspected that my mobile phone Wi-Fi signal was being knocked off by a nearby wireless network, and the screenshot shows how my Wi-Fi RSSI (received signal strength indication, green line) drops as I moved my wireless laptop around the building and back again. Details of a nearby BT home hub were detected, and the 'channels' tab showed some network overlap.

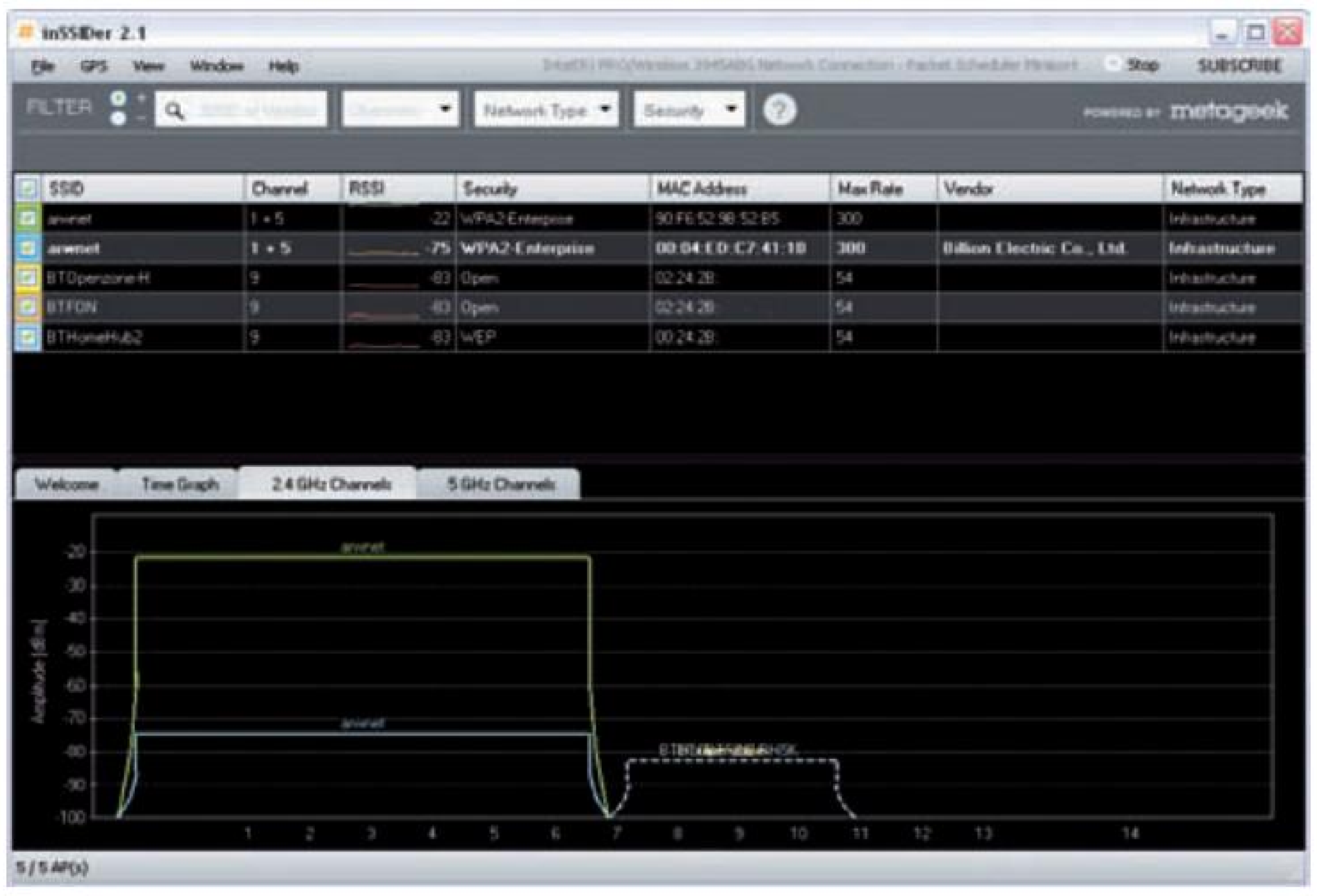
Several things could be done to help improve wireless strength. Few users actually consider the antennae and various types of directional Wi-Fi aerials are available on eBay for a few pounds. Possibly a desktop-mounting antenna on an extension lead might boost PC wireless cards in some cases. I decided on a more active approach though when the TP-Link TL-WA830RE 300Mbps Wireless N Range Extender caught my attention online. It's a small router-sized box that promises to increase the coverage of a 2.4GHz wireless network, and for about £30 I decided to give it a go.

Aimed at the domestic market, it's a budget-priced bit of kit, namely a small and typically warm plastic box with two antennae and a single Ethernet port. An Ethernet cable and mains adaptor are included, and it sports a button labelled 'Range Extender'.

I am often skeptical about any Wi-Fi 'Quick Start' guide and two setup methods were offered by TP-Link. The deceptively simple WPS (Wi-Fi Protected Setup) pushbutton connection means pressing the WPS button on the router (where equipped) and press the Range Extender button on the device for a few seconds to complete the setup – or that's what the guide would have you believe. After half an hour of fiddling I could not connect the range extender this way, despite digging into the router's myriad settings, ensuring that WPS was properly enabled and stabbing the buttons with my fingertip *ad nauseum*.

The second method is more sure-fire, and involves hooking the Range Extender to a PC via an Ethernet cable (supplied) and logging into it that way. This became a nuisance given the need (as I would soon learn) to search online for FAQs and support guidelines. There was an annoying period of swapping Ethernet cables in order to go back online again looking for more answers.

Typing the device's default IP address into my browser yielded nothing initially, but a blank stare from my screen, and eventually I found out why: with the PC disconnected from the router and working in standalone mode, according to the helpful FAQ on **http://uk.tp-link.com/article/?id=375** a static IP needs assigning temporarily to that PC. After doing so (the FAQ refers to Windows XP only, not Windows 7) I logged into the range extender successfully. The wireless security details and network key were set and the device's settings were configured rapidly, remembering to restore the PC's IP settings afterwards. After this performance, the device's 'Range Extender' LED glowed triumphantly and seemed quite stable. At the same time, I logged into my router to change the wireless channel and eliminate the conflict with neighbouring networks.



SSID	Channel	RSSI	Security	MAC Address	Max Rate	Vendor	Network Type
arwnet	1 + 5	-22	WPA2-Enterprise	90:F6:52:98:52:E5	300		Infrastructure
arwnet	1 + 5	-75	WPA2-Enterprise	00:04:ED:C7:41:10	300	Billion Electric Co., Ltd.	Infrastructure
BTOpenzone-H	9	-83	Open	02:24:2B:	54		Infrastructure
BTFON	9	-83	Open	02:24:2B:	54		Infrastructure
BTHomeHub2	9	-83	WEP	00:24:2B:	54		Infrastructure

Logging into the router to change Wi-Fi channels avoided conflicts with a neighbouring network. The green trace is the TP-Link range extender placed nearby. The blue trace is the wireless router

A DC extension cable for the adaptor was sourced from Amazon (also available from CPC) and the TP-Link Range Extender was located in a spare room for a trial period. What difference did the device make to my network? My Windows Mobile phone initially reported better Wi-Fi signal strength (four or five bars) as did my wireless laptop. Mobile surfing seemed somewhat snappier and a PC with Wi-Fi card seems to connect more consistently too – some of the time anyway.

Disappointingly though, I would find that the link dropped quite regularly and a reboot was needed several times a day. After a promising start, inSIDDer showed how the wireless extender signal would fade out, sometimes every minute or two. I wasn't convinced that the budget-priced device performed consistently enough and in the end I abandoned the idea. The packaging promised to 'extend existing wireless networks in as little as a few seconds at the push of a button' but in my experience the reality was rather different; the average user who has no experience of networking setup would probably struggle with setting up this device, whichever 'quick start' method they chose.

The TP-Link TL-WA830RE (300Mbps) is available from Amazon UK and alternatives include a more expensive plug-top style Billions BiPac 3100SN Access Point Repeater which can only be positioned, of course, where there's a mains socket. Another alternative would be Powerline adaptors (Ethernet through the mains), which is a genuinely simple approach to extending the network.

TP-LINK
TL-WA830RE
300Mbps Wireless N Range Extender
Power
System
LAN
WLAN

Trail blazing

In December 2011's *Net Work* I mentioned Amazon's new Kindle Fire, a colour-version of their immensely popular ebook reader. It cost $199, but would not make it to the UK until now. The tablet market is hotting up with intense competition from the iPad, Google's Nexus 7 and Samsung Galaxy Tab as the big brands slug it out amongst themselves, with Samsung in the USA licking its wounds after a bruising battle with Apple over intellectual property.

Amazon claims that the latest Kindle offers a 40% improvement, and the original USA-only Kindle Fire is now upgraded but costs just £129. The new Kindle Fire HD is £159 (16GB) or £199 (32GB). Both devices launch on to the UK market on 25 October, just in time for Christmas. At the time of writing the Kindle can be pre-ordered from **Amazon.co.uk**. With the launch of Windows 8 and Microsoft Surface (see last month) as well, October will be a busy month in the run-up to Christmas.

That's all for this month's *Net Work*. You can write to me at: **alan@epemag.demon.co.uk** or share your views with the editor at: **editorial@wimborne.co.uk**. Your letter might feature in *Readout* and you could win a prize!

READOUT

Matt Pulzer addresses some of the general points readers have raised. Have you anything interesting to say? **Drop us a line!**

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All letters quoted here have previously been replied to directly

Email: editorial@wimborne.co.uk

☆ LETTER OF THE MONTH ☆

Upgrading a discharge circuit

Dear editor
Having read the *Electrolytic Capacitor Reformer and Tester* (Aug/Sept '12) articles, it occurs to me that there is a better way for the failsafe discharge circuit. Instead of a series pair of 1kΩ 1W resistors, a more effective 'energy dump' is the inrush-limiting NTC thermistor often found preceding the bridge rectifier in switch-mode PSUs.

The room temperature resistance can be selected by type from a few tens to a few thousand ohms, the energy in the capacitor heats the NTC thermistor causing the resistance to fall – this discharges high voltage capacitors to a safe voltage far more rapidly than normal 'dump' resistors.

I have been using a similar NTC dump in a slightly different application for a number of years. In actual fact, my application is a Zener tester that works up to any voltage I'm ever likely to encounter. It starts with a voltage-doubling bridge rectifier with a pair of 180µF electrolytics. This is fed from the mains via a series pair of 68kΩ 2W resistors (liberated from the UC3842 start-up circuit in a PC monitor PSU).

The voltage doesn't quite reach 640V – I suspect the mains-rated bridge rectifier module starts to impose leakage, so the voltage just about creeps up above 600V.

The Mk1 had a shorting switch to dump the charge on the capacitors – that only lasted for one operation! The inclusion of an inrush-limiting NTC thermistor has protected the replacement switch ever since.

On rare occasions; my device has successfully been used to reform high voltage electrolytics.

Ian Field, by email

Matt Pulzer replies:

A fascinating alternative Ian, thank you for your suggestion. As always, EPE *readers can be relied upon to improve our projects.*

More on mains safety

Dear editor
Your editorial ('Don't let electrical familiarity breed contempt', *EPE*, July 2012) highlights the need for regular inspection of electrical installations and the close attention IT equipment needs.

A couple of months ago a similar thing to the one you described happened to me. The neutral pin of a plug attached to an electric toaster overheated, the screw had become loose. (A useful reminder that the (small) extra cost of plugs and sockets from the likes of British manufacturer MK is worth every penny; budget plugs and sockets use the minimum of materials.)

The proliferation of double-insulated IT switch-mode power supplies can result in a significant earth-leakage current, which can flow via low voltage outputs to a desktop PC's earth connection, or more dangerously to *you* if you're using a laptop – no prize for guessing how I discovered this!

Switch-mode power supplies often have a capacitor connecting the negative side of the mains bridge rectifier to the negative DC output terminal. DVD players and digital set-top boxes also have a capacitor connecting one terminal of the non-polarised mains inlet to the metal enclosure. With the rise of switch-mode power supplies used to power IT equipment, it's easy to underestimate the effect of the high level of pulsed current taken from the mains.

Most computers no longer have a 'real' on/off switch to isolate the PC and monitor supply. I thought I'd try one of those master/slave multi-way power adaptors to make it easier to properly switch off the monitor and the peripherals, but after a week the relay contacts welded together. Perhaps these hidden dangers could be the subject of an article some time soon.

John Swift, Prescot, Merseyside, via email

Matt Pulzer replies:

A good idea John – I will look into it.

Hearing loop projects

Dear editor
Being profoundly deaf in one ear and not much better in the other, I'm really hoping that I can get some mileage out of the hearing loop receiver articles you are running. I use a commercial product called the Sennheiser RR840S with reasonable success. This has a driver/charger unit that accepts the headphone output signal from the TV and sends it to the loop system you hang around your neck, but with my terrible hearing it only just about works. The beauty of it is, instead of receiving from the loop, I can as an alternative, plug-in a pair of Telecoil equipped headphones, which give me increased amplification, but which are a bit clumsy to use.

There are many people in the UK that are deaf, and we do need good quality information. Many times, when looking for a hearing aid – NHS or privately sourced – I get fobbed off with a white-coated idiot with no qualifications pretending to offer a 'consultation', which just means he sits at a box, preprogramed to send various tones at various amplitudes and the results get fed into a computer, which in turn sets up the hearing aid.

As a consumer, it feels like a completely closed shop. Recently, we've had a breakthrough in the price-fixing wars because you can get hearing aids from about £90 now, but of course a couple of the well-known national suppliers try and convince you that you need to spend anything from £1000 to £3500, and the latest fairytale is if you need two hearing aids they should have Bluetooth built-in to talk to one another to provide you with the 'best possible' response to your problems.

Incidentally, I do hope your hearing loop receiver is designed to cope with the profoundly deaf, because most hearing aids I see advertised are only there for people with mild hearing losses of 50dB or less So, a possible future article could well be a box of tricks with the ability to transmit tones at various strengths up to at least 6kHz and which can graph results.

GS Chatley, by email

Matt Pulzer replies:

I hope you enjoy the hearing loop series George, and we will welcome feedback from anyone with hearing loss, telling how well the projects have worked!

Loops and inductors

Dear Editor

I would like to express my appreciation for your excellent and much-needed series on Inductive Loops.

With reference to the *Hearing Loop Receiver (Sept'12)*, would it not be feasible to fit two inductors (L1) at right angles to minimise the effects of the orientation of the unit relative to the plane of the loop?

Geoffrey Evans

Project designer John Clarke from Silicon Chip *magazine replies:*

Hi Geoffrey

A second inductor could be included at right angles to the other, and connected in series. Generally, the hearing loop receiver is used in the upright orientation and so there is no need for an alternative orientation inductor for pickup from the horizontal loop.

Legacy systems

Dear Alan

I have been trying to find the free download 'Toolkit TK3' from the November 2001 magazine. All I can find is some very expensive tutorial CDs, which include this free software. I need to convert your software written in this obscure assembler to MPLAB, which is what I normally use. The hex code on your website for the project I am building *Wind Speed Meter* (January 2003) is either corrupt or written in another strange format as it will not load into my programmer.

Sadly, you only have the TASM code which is not compatible with MPLAB. I fail to understand why you cannot supply the MPLAB version, as this is without doubt the most universal code available.

I have recently purchased a CD-Rom of back issues over five years and since discovered almost all your PIC-based projects are written using this weird assembler.

Adrian Anderson, by email

Alan Winstanley replies:

Dear Adrian

I am sorry to hear your views about EPE*. Regular readers recognise that our own PIC micro projects evolved from the 1990s and were written using TASM. Some of the items you mention are now a decade old, but we may republish our legacy material on new CDs periodically. Various tutorials and series that we published over the years ensure that all our work is fully supported in the environment that the authors used at that time.*

While MPLAB was not widely used in our own hobbyist market in those days (and the choice of microcontroller family complicated things even more), today it is obviously true that Microchip's own software is now widely accessible and we still focus almost exclusively on using PIC micros. In fact, we enjoy a very close relationship with Microchip today, but we have provided plenty of support and high-value software tools of our own, including our Toolkit TK3 that enabled readers to complete these projects successfully at that time.

Unfortunately, if you wish to use a different set of tools on a legacy project then we cannot directly provide support for that. The question of MPASM/TASM conversion is settled, and many readers have addressed this very successfully with little effort. The best place to be is **www.chatzones.co.uk** *where plenty of help is available from fellow* EPE *readers on this precise subject.*

Toolkit TK3 is available for free download just as it has always been. The late John Becker, our technical editor, developed it entirely in-house. His material was the foundation for many highly successful constructional projects and tutorials that were unique and highly prized by their followers.

ftp://ftp.epemag.wimborne.co.uk/pub/PICS/

If you prefer a web-based front end to our legacy file library please visit:

http://www.epemag.net/microcontroller-code.htm

At the same time, we bundle our PIC software library on to CD for convenience and have often included them as cover mounts or free CDs. I have personally mastered the cover disks for this.

The Wind Speed Meter *files are not corrupt, but we will not be providing a conversion tool for legacy codes either now or in the future. As mentioned, plenty of enthusiastic support is available in the* EPE Chat Zone *from people eager to help. We have yet to come across any such problem with a legacy file that a friendly exchange in the forum has not resolved.*

Alan Winstanley,
EPE online editor

Readers can contact Alan by email at: ***alan@epemag.demon.co.uk***

Interfacing the Arduino

Dear Editor

Now that the Arduino is available at affordable prices and is taking off in popularity worldwide, what about the possibility of publishing some useful articles on how to interface them to the real world? They are a lot easier to use than PICs, and for beginners, I would say cheaper, if you take into account all the extras you need to get going. PICs may be more appropriate for professionals, but for hobbyists, the Arduino is ideal.

There is material around in *Make Magazine, Nuts & Volts*, and online in *Instructables*, but it would be nice if we could see some ideas coming from the UK... and you are the only game in town!

What I particularly like is the way they are programmable from a standardised high-level language. Many of your past projects that involve PICs could profit from a reworking.

A case in point would be the March 2006 *Telescope Interface* – one of the very fine projects by the late John Becker. Unfortunately, the software was written in TK3 assembler, and I found it quite hard to follow, and as a result, I still haven't gotten around to making it. (I don't even think the old TK3 assembly code is available for download now; all I found in the library was source code of the *RS485 Master Device* by Mike Hibbett. I will now attempt it using an Arduino, but it would be very nice if projects like these were updated.

That was the other thing about those old PIC projects. The code was available to download, but there was never a description of the algorithms, flowcharts or anything like that. This wasn't peculiar to John, it still persists today. I think for anyone who wants to be able to modify, adapt, or design for themselves, it would be extremely helpful to see how the code works – it is arguably as pertinent as understanding how to configure an op amp in the old days.

Using an Arduino would help in that, because the processing language used to program them makes the whole situation a lot more transparent.

Brian Williams (reader since the 1960s)

Matt Pulzer replies:

Thank you for your letter Brian. There are so many inspiring silicon options out there, it is difficult to cover them all. At the moment, we are deliberately concentrating on PICs and the new Raspberry Pi. I do think it is important to do a few things well, rather than trying to cover many controllers without any real depth. That said, we are always open to suggestions and Arduino would certainly be a contender if we ever changed track

IF YOU HAVE A SUBJECT YOU WISH TO DISCUSS IN READOUT PLEASE EMAIL US AT:

editorial@wimborne.co.uk

DIRECT BOOK SERVICE

ELECTRONICS TEACH-IN BUNDLE – SPECIAL BUNDLE PRICE £14 FOR PARTS 1, 2 & 3

FREE CD-ROM

ELECTRONICS TEACH-IN 2 CD-ROM USING PIC MICROCONTROLLERS A PRACTICAL INTRODUCTION

This *Teach-In* series of articles was originally published in *EPE* in 2008 and, following demand from readers, has now been collected together in the *Electronics Teach-In 2* CD-ROM.

The series is aimed at those using PIC microcontrollers for the first time. Each part of the series includes breadboard layouts to aid understanding and a simple programmer project is provided.

Also included are 29 *PIC N' Mix* articles, also republished from *EPE*. These provide a host of practical programming and interfacing information, mainly for those that have already got to grips with using PIC microcontrollers. An extra four part beginners guide to using the C programing language for PIC microcontrollers is also included.

The CD-ROM also contains all of the software for the *Teach-In 2* series and *PIC N' Mix* articles, plus a range of items from Microchip – the manufacturers of the PIC microcontrollers. The material has been compiled by Wimborne Publishing Ltd. with the assistance of Microchip Technology Inc.

The Microchip items are: MPLAB Integrated Development Environment V8.20; Microchip Advance Parts Selector V2.32; Treelink; Motor Control Solutions; 16-bit Embedded Solutions; 16-bit Tool Solutions; Human Interface Solutions; 8-bit PIC Microcontrollers; PIC24 Micrcontrollers; PIC32 Microcontroller Family with USB On-The-Go; dsPIC Digital Signal Controllers.

CD-ROM **Order code ETI2 CD-ROM** **£9.50**

ELECTRONICS TEACH-IN 3

The three sections of this book cover a very wide range of subjects that will interest everyone involved in electronics, from hobbyists and students to professionals. The first 80-odd pages of Teach-In 3 are dedicated to *Circuit Surgery*, the regular *EPE* clinic dealing with readers' queries on various circuit design and application problems – everything from voltage regulation to using SPICE circuit simulation software.

The second section – *Practically Speaking* – covers the practical aspects of electronics construction. Again, a whole range of subjects, from soldering to avoiding problems with static electricity and indentifying components, are covered. Finally, our collection of *Ingenuity Unlimited* circuits provides over 40 circuit designs submitted by the readers of *EPE*.

The free cover-mounted CD-ROM is the complete *Electronics Teach-In 1* book, which provides a broad-based introduction to electronics in PDF form, plus interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In 1 series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The Teach-In 1 series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC. There is also a MW/LW Radio project in the series. The contents of the book and Free CD-ROM have been reprinted from past issues of *EPE*.

160 pages **Order code ETI3** **£8.50**

Book and CD-ROMs **Order code ETIBUNDLE** Bundle Price **£14.00**

NEW

ELECTRONICS TEACH-IN 4

FREE CD-ROM

ELECTRONICS TEACH-IN 4

A Broad-Based Introduction to Electronics plus FREE CD-ROM

The Teach-In 4 book covers three of the most important electronics units that are currently studied in many schools and colleges. These include, Edexcel BTEC level 2 awards and the electronics units of the new Diploma in Engineering, Level 2.

The Free cover-mounted CD-ROM contains the full Modern Electronics Manual, worth £29.95. The Manual contains over 800 pages of electronics theory, projects, data, assembly instructions and web links.

A package of exceptional value that will appeal to all those interested in learning about electronics or brushing up on their theory, be they hobbyists, students or professionals.

Available NOW – see page 24 in this issue for details

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS AND CDROMS SEE THE UK SHOP ON OUR WEBSITE

www.epemag.com

All prices include UK postage

2

COMPUTING AND ROBOTICS

WINDOWS XP EXPLAINED
N. Kantaris and P. R. M. Oliver

If you want to know what to do next when confronted with Microsoft's Windows XP screen, then this book is for you. It applies to both the Professional and home editions.

The book was written with the non-expert, busy person in mind. It explains what hardware requirements you need in order to run Windows XP successfully, and gives an overview of the Windows XP environment.

The book explains: How to manipulate Windows, and how to use the Control Panel to add or change your printer, and control your display; How to control information using WordPad, notepad and paint, and how to use the Clipboard facility to transfer information between Windows applications; How to be in control of your filing system using Windows Explorer and My Computer; How to control printers, fonts, characters, multimedia and images, and how to add hardware and software to your system; How to configure your system to communicate with the outside world, and use Outlook Express for all your email requirements; how to use the Windows Media Player 8 to play your CDs, burn CDs with your favourite tracks, use the Radio Tuner, transfer your videos to your PC, and how to use the Sound Recorder and Movie Maker; How to use the System Tools to restore your system to a previously working state, using Microsoft's Website to update your Windows set-up, how to clean up, defragment and scan your hard disk, and how to backup and restore your data; How to successfully transfer text from those old but cherished MS-DOS programs.

264 pages **Order code BP514** **£7.99**

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold

Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various "click-together" components supplied in the basic RIS kit. explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

Detailed building and programming instructions provided, including numerous step-by-step photographs.

288 pages + Large Format **Order code BP901** **£14.99**

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Covers the Vision command system

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

298 pages **Order code BP902** **£14.99**

THE PIC MICROCONTROLLER YOUR PERSONAL INTRODUCTORY COURSE – THIRD EDITION John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised third edition covers the popular reprogrammable Flash PICs: 16F54/16F84 as well as the 12F508 and 12F675.

270 pages **Order code NE36** **£25.00**

INTRODUCTION TO MICROPROCESSORS AND MICROCONTROLLERS – SECOND EDITION
John Crisp

If you are, or soon will be, involved in the use of microprocessors and microcontrollers, this practical introduction is essential reading. This book provides a thoroughly readable introduction to microprocessors and micrcontrollers. Assuming no previous knowledge of the subject, nor a technical or mathematical background. It is suitable for students, technicians, engineers and hobbyists, and covers the full range of modern micros.

After a thorough introduction to the subject, ideas are developed progressively in a well-structured format. All technical terms are carefully introduced and subjects which have proved difficult, for example 2's complement, are clearly explained. John Crisp covers the complete range of microprocessors from the popular 4-bit and 8-bit designs to today's super-fast 32-bit and 64-bit versions that power PCs and engine management systems etc.

222 pages **Order code NE31** **£29.99**

EASY PC CASE MODDING
R.A Penfold

Why not turn that anonymous grey tower, that is the heart of your computer system, into a source of visual wonderment and fascination. To start, you need to change the case or some case panels for ones that are transparent. This will then allow the inside of your computer and it's working parts to be clearly visible.

There are now numerous accessories that are relatively inexpensive and freely available, for those wishing to customise their PC with added colour and light. Cables and fans can be made to glow, interior lights can be added, and it can all be seen to good effect through the transparent case. Exterior lighting and many other attractive accessories may also be fitted.

This, in essence, is case modding or PC Customising as it is sometimes called and this book provides all the practical details you need for using the main types of case modding components including:- Electro luminescent (EL) 'go-faster' stripes: Internal lighting units: Fancy EL panels: Data cables with built-in lighting: Data cables that glow with the aid of 'black' light from an ultraviolet (UV) tube: Digital display panels: LED case and heatsink fans: Coloured power supply covers.

192 pages + CD-ROM **Order code BP542** **£8.99**

ROBOT BUILDERS COOKBOOK
Owen Bishop

This is a project book and guide for anyone who wants to build and design robots that work first time.

With this book you can get up and running quickly, building fun and intriguing robots from step-by-step instructions. Through hands-on project work, Owen introduces the programming, electronics and mechanics involved in practical robot design-and-build. The use of the PIC microcontroller throughout provides a painless introduction to programming – harnessing the power of a highly popular microcontroller used by students, hobbyists and design engineers worldwide.

Ideal for first-time robot builders, advanced builders wanting to know more about programming robots, and students tackling microcontroller-based practical work and labs.

The book's companion website at http://books.elsevier.com/companions/9780750665568 contains: downloadable files of all the programs and subroutines; program listings for the Quester and the Gantry robots that are too long to be included in the book.

366 pages **Order code NE46** **£26.00**

THEORY AND REFERENCE

GETTING THE MOST FROM YOUR MULTIMETER

R. A. PenfoldM

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**

OSCILLOSCOPES – FIFTH EDITION

Ian Hickman

Oscilloscopes are essential tools for checking circuit operation and diagnosing faults, and an enormous range of models are available.

This handy guide to oscilloscopes is essential reading for anyone who has to use a 'scope for their work or hobby; electronics designers, technicians, anyone in industry involved in test and measurement, electronics enthusiasts . . . Ian Hickman's review of all the latest types of 'scope currently available will prove especially useful for anyone planning to buy – or even build – an oscilloscope.

The contents include a description of the basic oscillscope; Advanced real-time oscilloscope; Accessories; Using oscilloscopes; Sampling oscilloscopes; Digital storage oscilloscopes; Oscilloscopes for special purposes; How oscillocopes work (1): the CRT; How oscilloscopes work (2): circuitry; How oscilloscopes work (3): storage CRTs; plus a listing of Oscilloscope manufacturers and suppliers.

288 pages **Order code NE37** **£36.99**

UNDERSTANDING ELECTRONIC CONTROL SYSTEMS

Owen Bishop

Owen Bishop has produced a concise, readable text to introduce a wide range of students, technicians and professionals to an important area of electronics. Control is a highly mathematical subject, but here maths is kept to a minimum, with flow charts to illustrate principles and techniques instead of equations.

Cutting edge topics such as microcontrollers, neural networks and fuzzy control are all here, making this an ideal refresher course for those working in Industry. Basic principles, control algorithms and hardwired control systems are also fully covered so the resulting book is a comprehensive text and well suited to college courses or background reading for university students.

The text is supported by questions under the headings Keeping Up and Test Your Knowledge so that the reader can develop a sound understanding and the ability to apply the techniques they are learning.

228 pages **Order code NE35** **£36.99**

A BEGINNER'S GUIDE TO TTL DIGITAL ICs

R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages **Order code BP332** **£5.45**

MICROCONTROLLER COOKBOOK

Mike James

The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

240 pages **Order code NE26** **£36.99**

FULL COLOUR COMPUTING BOOKS

HOW TO FIX YOUR PC PROBLEMS

R.A. Penfold

What do you do when your laptop or desktop stops working properly. Do you panic, try to find the answer on the page of fault finding tips you may find at the back of the manufacturers manual. Or do you spend hours trying to get through to a telephone helpline or waste even more time waiting for an email reply from a helpdesk.

Well help is now at hand! This book will assist you in identifying the type of problem, whether it's hardware, software or a peripheral that is playing up? Once the fault has been identified, the book will then show you how to go about fixing it. This book uses plain English and avoids technical jargon wherever possible. It is also written in a practical and friendly manner and is logically arranged for easy reference.

The book is divided into four main sections and among the many topics covered are: Common problems with Windows Vista operating system not covered in other chapters. Also covers to a lesser extent Windows XP problems. Sorting out problems with ports, peripherals and leads. Also covers device drivers software and using monitoring software. Common problems with hard disc drives including partitioning and formatting a new drive. Using system restore and recovering files. Also covers CD-ROM and Flash drives. Common problems with sound and video, including getting a multi-speaker system set up correctly.

An extremely useful addition to the library of all computer users, as you never know when a fault may occur!

Printed in full colour on high quality non-refective paper

128 pages **Order code BP705** **£8.49**

AN INTRODUCTION TO WINDOWS VISTA

P.R.M. Oliver and N. Kantarris

If you have recently bought a new desktop or laptop it will almost certainly have Windows as its operating system. Windows Vista manages the available resource of a computer and also 'controls' the programs that run on it.

To get the most from your computer, it is important that you have a good understanding of Vista. This book will help you acheive just that. It is written in a friendly and practical way and is suitable for all age groups from youngsters to the older generation. It has been assumed that Vista is installed and running on your computer.

Among the numerous topics explained are: The Vista environment with its many windows. How to organise your files, folders and photos. How to use Internet Explorer for your web browsing. How to use Microsoft Mail for your emails. How to control your PC and keep it healthy. How to use Vista's Accessibility features if you have poor eye sight or difficulty in using the keyboard or mouse. And much more besides....

With the help of this book you will easily and enjoyably gain a better understanding of Microsoft's amazing Windows Vista operating system.

Printed in full colour on high quality non-refective paper

120 pages **Order code BP703** **£8.49**

COMPUTING WITH A LAPTOP FOR THE OLDER GENERATION

R.A. Penfold

Laptop computers have rapidly fallen in price, increased in specification and performance and become much lighter in weight. They can be used practically anywhere, then stored away out of sight. It is therefore, not surprising that laptop sales now far exceed those of desktop machines and that they are increasingly becoming the machine of choice for the older generation.

You may want to use your laptop as your main computer or as an extra machine. You may want to use your laptop on the move, at home, at work or on holiday. Whatever your specific requirements are, the friendly and practical approach of this book will help you to understand and get the most from your laptop PC in an easy and enjoyable way. It is written in plain English and wherever possible avoids technical jargon.

Among the many topics covered are: Choosing a laptop that suits your particular needs. Getting your new computer set up properly. Customising your computer so that it is optimised for your particular needs. Setting up and dealing with user accounts. Using the Windows 'Ease of Access Center'. Optimising the life and condition of your battery. Keeping the operating system and other software fully up-to-date. Troubleshooting common problems. Keeping your computer and data safe and secure. And much more besides...

Even though this book is written for the older generation, it is also suitable for anyone of any age who has a laptop or is thinking of buying one. It is written for computers that use Windows Vista as their operating system but much will still apply to Windows XP machines.

Printed in full colour on high quality non-refective paper

120 pages **Order code BP702** **£8.49**

AN INTRODUCTION TO EXCEL SPREADSHEETS

Jim Gatenby

The practical and friendly approach of this book will help newcomers to easily learn and understand the basics of spreadsheets. This book is based on Microsoft's Excel 2007 spreadsheet, but much of the book will still apply to earlier versions of Excel. The book is written in plain English, avoiding technical and mathematical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.

Among the many topics explained are how to: Install the software. Use the exciting new features of Excel 2007. Create and use a spreadsheet. Enter, edit and format text, numbers and formulae. Insert and delete columns and rows. Save and print a spreadsheet. Present the information on a spreadsheet as a graph or chart. Manage and safeguard Excel files on disc. Use Excel as a simple database for names and addresses.

This book will help you to quickly gain confidence and get to grips with using spreadsheets. In fact, you will wonder how you ever managed without them.

Printed in full colour on high quality non-reflective paper.

118 pages **Order code BP701** **£8.49**

AN INTRODUCTION TO DIGITAL PHOTOGRAPHY WITH VISTA

R.A. Penfold

The friendly and practical approach of this book will help newcomers to digital photography and computing to easily learn the basics they will need when using a digital camera with a laptop or desktop PC. It is assumed that your PC uses Windows Vista, however, if it is a Windows XP machine the vast majority of this book will still apply. The book is written in plain English, avoiding technical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.

Among the many topics explained are how to: Understand the basic features of a digital camera. Transfer photographs from your digital camera to your computer. View your photographs. Save, sort and file your photographs. Manipulate, crop and carry out simple corrections to your photographs. Copy your photographs on to CD or DVD. Print your photographs. Share images with family and friends anywhere in the world by email or with an online album.

This book will help you quickly get to grips with, gain confidence and expand your horizons in the fascinating hobby of digital photography.

Printed in full colour on high quality non-reflective paper.

120 pages **Order code BP700** **£8.49**

COMPUTING & PROJECT BUILDING

eBAY – TWEAKS, TIPS AND TRICKS

NEW

R. A. Penfold

Online auction sites are one of the most popular types of site on the internet, and the most popular of these is the eBay site. On eBay you can buy and sell practically anything at surprisingly low cost, and all from the comfort of your armchair!

This book contains numerous tweaks, tips and tricks covering various aspects of buying and selling on eBay. These tweaks, tips and tricks will help both new and more experienced users of the site to make the most of eBay's facilities while remaining safe and secure.

Among the many topics covered are: Finding the items you require using the eBay search facility: Getting the best prices when buying and selling on eBay: Avoiding both buying and selling scams: Determining the market value for items you intend buying or selling: How to avoid problems that may arise when buying and selling on eBay: Making the most of the various facilities that are built into the eBay site: How to take good photos of items you wish to sell using basic equipment: Using the My eBay page to stay in control of your buying and selling activities: And more besides.

128 pages **Order code BP716** £7.50

THE INTERNET – TWEAKS, TIPS AND TRICKS

NEW

R. A. Penfold

Robert uses his vast knowledge and experience in computing to provide you with useful hints, tips and warnings about possible difficulties and pitfalls when using the Internet. This book should enable you to get more from the Internet and to discover ways and means of using it that you may not have previously realised.

Among the many topics covered are: Choosing a suitable browser: Getting awkward pages to display properly: Using Java, spell checkers and other add-ons: Using proxy servers to surf anonymously and privacy facilities so you do not leave a trail of sites visited. Ways of finding recently visited sites you can no longer find: Using download managers to speed up downloads from slow servers. Plus, effective ways and tricks of using search engines to locate relevant info: Tricks and tips on finding the best price for goods and services: Not getting "conned" when buying or selling on eBay: Finding free software: Finding and using the increasing range of Cloud computing services: Tips on selecting the best security settings: Etc,etc,etc.

128 pages **Order code BP721** £7.50

FREE DOWNLOADS TO PEP-UP AND PROTECT YOUR PCS

NEW

R. A. Penfold

Robert uses his vast knowledge and experience in computing to guide the reader simply through the process of finding reliable sites and sources of free software that will help optimise the performance and protect their computer against most types of malicious attack.

Among the many topics covered are: Using Windows 7 optimisation wizard: Using Pitstop for advice on improving performance, reducing start up times, etc: Free optimisation scans and the possibility of these being used as a ploy to attack your PC.

Plus, free programs such as Ccleaner, Registry checker and PCPal optimisation software: Internet speed testing sites and download managers: Overclocking sites together with warnings about using this technique: Sites and software for diagnosis of hardware faults, including scanning for out of date drivers and finding suitable replacements: Free Antivirus software and programs that combat specific types of malware: Firewalls: Search engines to identify mystery processes listed in Windows Task Manager.

128 pages **Order code BP722** £7.50

HOW TO BUILD A COMPUTER

R.A. Penfold

To build your own computer is, actually, quite easy and does not require any special tools or skills. In fact, all that it requires is a screwdriver, pliers and some small spanners rather than a soldering iron! The parts required to build a computer are freely available and relatively inexpensive.

Obviously, a little technical knowledge is needed in order to buy the most suitable components, to connect everything together correctly and to set up the finished PC ready for use. This book will take you step-by-step through all the necessary procedures and is written in an easy to understand way. The latest hardware components are covered as is installing the Windows Vista operating system and troubleshooting.

320 pages **Order code BP591** £8.99

BUILDING VALVE AMPLIFIERS

Morgan Jones

The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.

A unique hands-on guide for anyone working with valve (tube in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.

Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

368 pages **Order code NE40** £29.00

PRACTICAL FIBRE-OPTIC PROJECTS

R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** £5.45

BOOK ORDERING DETAILS

All prices include UK postage. for postage to Europe (air) and the rest of the world (surface) please add £2 per book. For the rest of the world airmail add £3 per book. **Note: Overseas surface mail postage can take up to 10 weeks**. CD-ROM prices include VAT and/or postage to anywhere in the world. Send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or card details, Visa, Mastercard or Maestro to:

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MERLEY, WIMBORNE, DORSET, BH21 1UU.

Books are normally sent within seven days of receipt of order, but please allow 28 days for delivery – more for overseas orders. *Please check price and availability (see latest issue of* Everyday Practical Electronics*) before ordering from old lists.*

For a further selection of books see the next two issues of *EPE*.
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COMPUTING AND ROBOTICS

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Tony Fischer-Cripps

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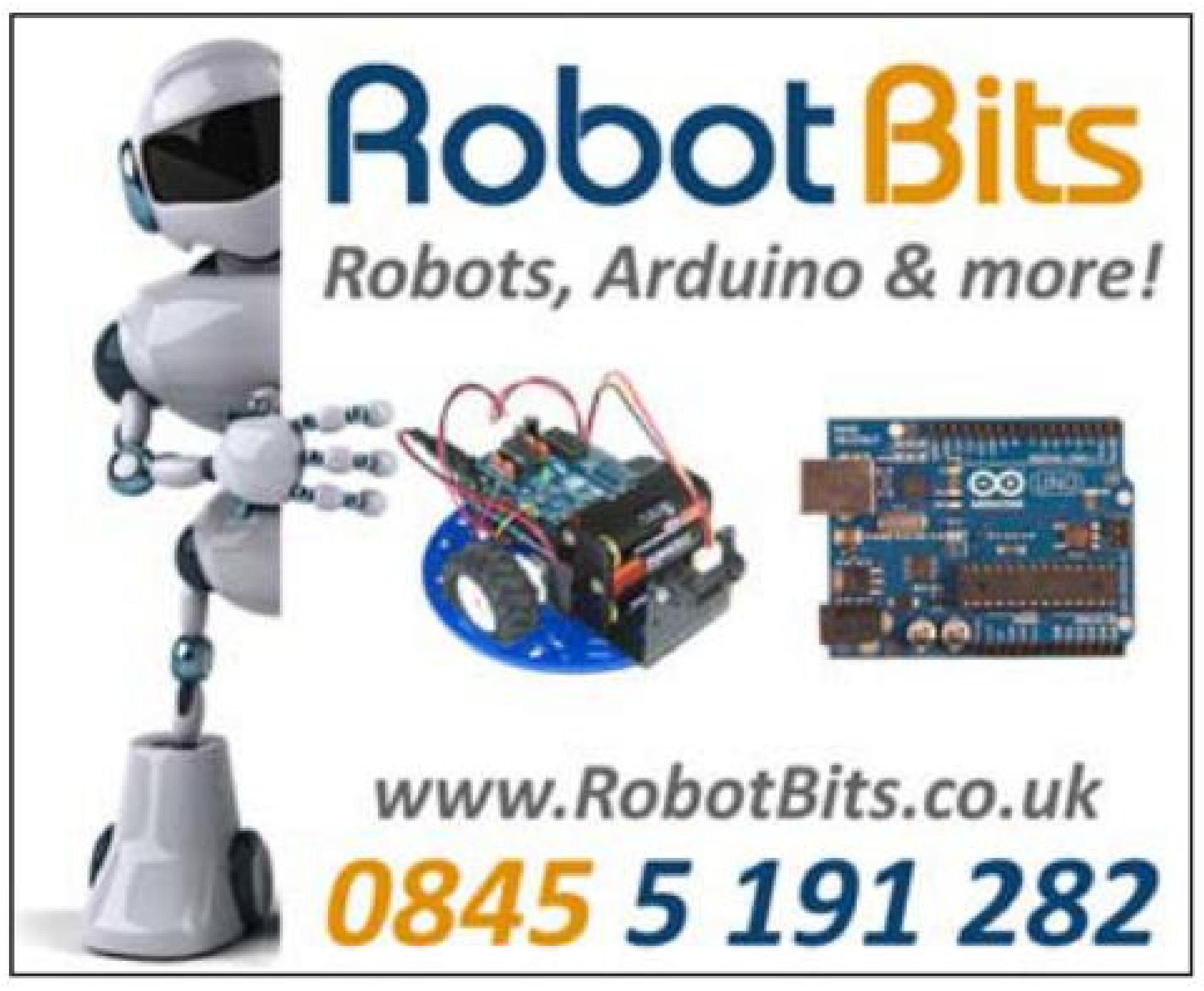
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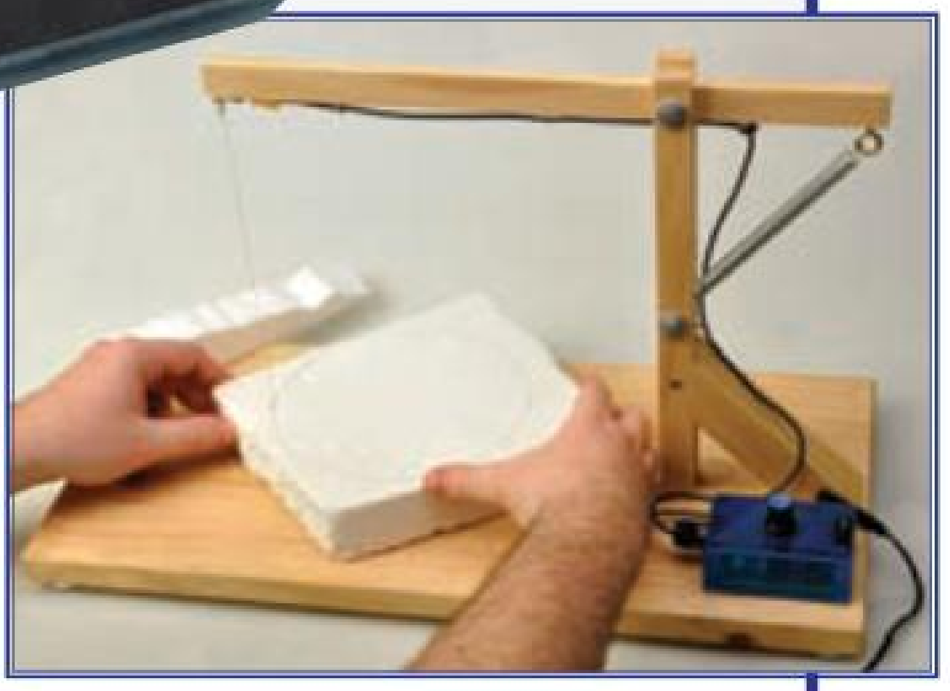
Next Month

Content may be subject to change

Universal USB Data Logger – Part 1

Based on a PIC micro, this simple, but useful project can log data to a memory card. It can read from many types of digital and analogue sensors, and features a real-time clock and calendar to 'time-stamp' the data.



Hot-wire cutter

Ever tried to cut polystyrene or polyurethane materials using a saw, razor blade or knife? The results are invariably less than satisfactory. If you are after a clean, precise cut, a hot-wire cutter is the answer. The hot wire actually melts the material and results in a very neat, very fine cut, without a snowstorm of flakes!

Hearing Loop Level Meter – Part 2

We show how to build a calibration coil and adjust the tester so that it gives accurate results. We also describe how the unit is used.

Digital Lighting Controller – Part 3

Christmas is just about here… well, it is autumn! Have you got your *Digital Lighting Controller* ready yet? In the first two articles we explained how the controller works and how to build it. This third article explains how to use the software – primarily the Windows-based sequencing program.

Jump Start

Not quite ready for our all singing and dancing *Digital Lighting Controller*? No problem, next up with *Jump Start* in December's *EPE* is a *Mini Christmas Lights* project; a fun and easy-to-build project for all levels of experience. This will be Mike and Richard Tooley's eighth project in our new series dedicated to newcomers, or those following courses taught in schools and colleges.

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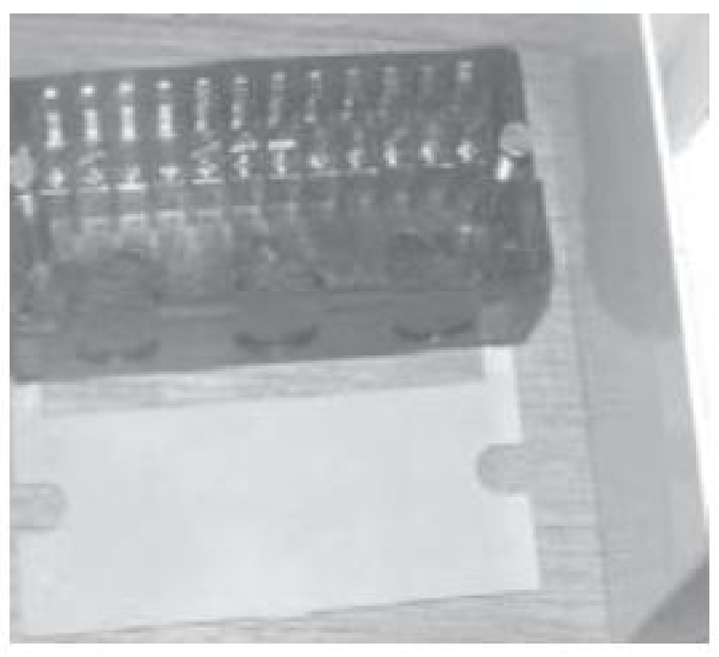

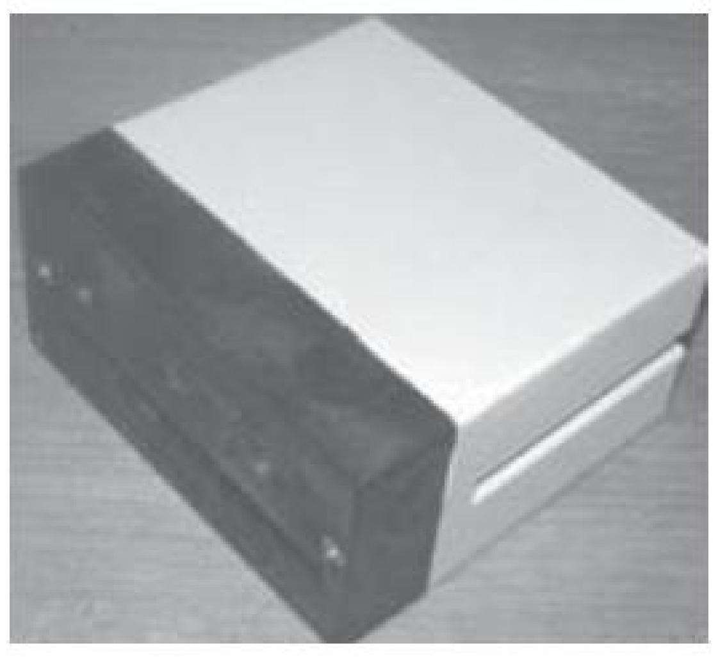

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